AIRPORT TECHNOLOGY

HEARING

BEFORE THE

SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

OF THE

COMMITTEE ON SCIENCE AND TECHNOLOGY HOUSE OF REPRESENTATIVES

NINETY-NINTH CONGRESS

SECOND SESSION

JULY 28, 1986

[No. 136]

Printed for the use of the
Committee on Science and Technology

U.S. GOVERNMENT PRINTING OFFICE

64-358 O WASHINGTON : 1986

For sale by the Superintendent of Documents, Congressional Sales Office
U.S. Government Printing Office, Washington, DC 20402

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CONTENTS

WITNESSES

	Page
July 28, 1986:	
Hon. Hank Brown, a Representative in Congress from the State of Colorado	2
Hon. Timothy E. Wirth, a Representative in Congress from the State of Colorado	3
George Doughty, director of aviation, city and county of Denver, Stapleton Airport	7
Dr. Raymond S. Colladay, Associate Administrator, Office of Aeronautics and Space Technology, National Aeronautics and Space Administration	15
Neal A. Blake, Deputy Associate Administrator for Engineering, Federal Aviation Administration	34
Dr. Walter Orr Roberts, president emeritus, university consortium for atmospheric research	61
William P. Mahoney, university consortium for atmospheric research	63
William B. Rourke, chairman of the board, Regional Transportation District, Denver, CO	73
Ronald L'Hommedieu, manager of construction, Dallas-Fort Worth International Airport	101
Leo Duggan, vice president, technical affairs, Airport Operators Council International, Washington, DC	107

AIRPORT TECHNOLOGY

MONDAY, JULY 28, 1986

HOUSE OF REPRESENTATIVES, COMMITTEE ON SCIENCE AND TECHNOLOGY, SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS,

Washington, DC.

The subcommittee met, pursuant to notice, at 10:15 a.m., in room 3211, Stapleton Airport, Denver, CO, Hon. George E. Brown, Jr., presiding.

Present: Representatives George E. Brown, Jr., Ron Packard, and Hank Brown.

Mr. GEORGE BROWN. We have a few lost staff members wandering around the airport, but they will stagger in. They probably have my gavel, but we will get along without it.

In the usual and customary procedure, the chairman and the ranking member will make brief, illuminating statements, which will explain why we are here. And I will start with mine.

The Subcommittee on Transportation, Aviation and Materials is pleased to be in Denver today to hear testimony on technology for future airports. It is particularly appropriate that we hold such a hearing in Denver because it is one of a very limited number of places in the country, maybe the only place, where a totally new airport can be constructed. As such, it gives the designers what may be a unique opportunity to incorporate the latest in technology and new design concepts.

In recent years, the subcommittee has supported a modest level of Federal research in a variety of areas related to airport design and construction. Today, we plan to review some of that research and evaluate whether it may be applicable to Denver's new airport.

To do that, we have invited a number of expert witnesses to address various technical questions that must be considered in such an undertaking. Among these are: The kinds of aircraft that may be flying in the early part of the 21st century that a new airport must serve; the future air traffic control environment in which the airport must operate; the new terminal design concepts for efficiently handling passengers and vehicles; advanced technology for predicting severe weather; and design concepts for reducing noise. I am sure you all recognize the importance of these latter factors.

Before we proceed with our first witness, I would like to recognize Mr. Ron Packard, our distinguished ranking minority member here today, for his opening statement.

Mr. PACKARD. Thank you, Mr. Chairman.

I am delighted to join you here in Denver, and the other members of this hearing board; especially those of you who are here representing these areas in Colorado.

I do not know that anyone could have predicted back in 1978 the full impact of airline deregulation. Surely, the hub-and-spoke route system that has evolved, and the tremendous pressures this has created for airports like Stapleton could not have been accurately forecast. The job that lies ahead for Denver will not be easy; meeting the demands of a critical aviation hub, while trying to satisfy the legitimate desires of its citizens for the quality of life they have grown accustomed to will be challenging.

The technology we have available today will help in meeting this challenge, but it will still take the determined efforts of a lot of people. I am sure many of those people are here today, and they will be very interested to hear about some of the progress that has been made in airport technology.

Mr. Chairman, the interest of this technology goes far beyond this room. As long as more and more Americans want to fly, we will continue to be challenged to meet that demand and at the same time make flying even safer.

You have assembled a distinguished group here this morning to testify on the subject. And I look forward to the hearing and to their testimony.

Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Thank you, Mr. Packard.

I would like to introduce a man who needs no introduction, our colleague, Mr. Hank Brown, a distinguished Member of Congress.

Do you have a statement you would like to make, Hank?

STATEMENT OF HON. HANK BROWN, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF COLORADO

Mr. HANK BROWN. Mr. Chairman, I particularly appreciate the committee's willingness to come to Colorado and hold this hearing. It is particularly appropriate, I think, in the field that you legislate it, to take a look at our problems here in Colorado.

When Stapleton was first located, it was really a visionary concept. It was placed out in the country at that time. It did not have homes around it. And, obviously, time has changed dramatically. We find ourselves with a critical problem here, that is not unlike many I know you have looked at around the country. But we face a critical problem of relocating a new airport, under new technology, under new circumstances, that will make it serviceable for the entire Rocky Mountain region, including Colorado. We particularly appreciate your help, your interest, and we look forward, as all Coloradans do, in working with you to help solve these problems.

Mr. GEORGE BROWN. Thank you, Hank.

I might say that we from California are looking forward to your solving your problem so it will help us solve our problem. We have the same kind of airport growth problems there in Los Angeles and Orange County and Ontario, where I flew in from this morning.

We are privileged to have as our first witness this morning a gentleman who as a member of this committee, is well acquainted with the programs of research and development, which the Con-

gress supports in this area. And also a Member of Congress from Colorado who is acquainted with the problems of this area, the Honorable Tim Wirth.

Tim, would you proceed with your testimony?

STATEMENT OF HON. TIMOTHY E. WIRTH, A REPRESENTATIVE IN CONGRESS FROM THE STATE OF COLORADO

Mr. WIRTH. Thank you very much, Mr. Chairman. I want to welcome you and Mr. Packard. I join with Hank Brown in welcoming you to Colorado, and the committee on which I have been privileged to sit for the last 11 years.

There is no better place, as Congressman Brown pointed out, to have this hearing, as we are in the process of starting to build a new airport from the ground up, moving away from an airport which, as Congressman Brown pointed out, was an innovation when it was first started. And it is now time to move on to the next generation.

I might add that my first flight out of here was in 1943, I believe, when Continental Airlines would come to your house and pick you up and take you out to the airplane. We are a long way from that particular technology.

We have the opportunity to start from the ground up and to involve all of the new technologies.

I think all of us in public office, at least I hope so, in the Colorado area would emphasize over and over the enormous importance of building a new airport and doing that expeditiously. Transportation, as we know, has always been an enormously important variable in the fabric of our economy, going back to canals, and then the railroads, and then the interstate system. We are now blessed with the new technologies of electronic freeways and jet airplanes. And the jet airplane brings with it great opportunity for economic growth; and as you pointed out, Mr. Chairman, also some significant downsides, if it is not done appropriately.

We are hoping that all of us can learn a great deal from the Dallas and the Atlanta experience and the importance there. Those airports have been incredible engines for economic growth in those communities, and a catalyst for a whole broad network of activity that has gone on there, and can go on here; reaching all the way across the State of Colorado and, in fact, the whole region; and that the planning system that we have here will bring in all of the small communities in the whole Colorado area, which are so dependent on this airport and recreation opportunity.

Having said that, and the importance of the endeavor that you are embarked upon and we are embarked upon here, let me touch briefly on a couple of other areas. First of all, safety.

Congressman Packard pointed out that in some areas we did not recognize what was going to happen with deregulation. It was certainly, however, not the intent of the Congress in any way, shape, or form, when airlines were deregulated, that we would deregulate safety. That has not been our intent in any way, shape, or form.

We had a hearing here 6 weeks ago, with Congressman Mineta, who chairs the Public Works Subcommittee. At that hearing on airline safety, it was very clear from almost all of the witnesses

that the margin of safety under which we have been operating has been shrinking. And that is something we cannot allow to happen, particularly at a time when we have a balance in the airport trust fund. There is no reason at all not to commit all of the resources that are necessary to assure a full and fair balance of safety.

Now, in that area, weather and weather research becomes enormously important. And as you know, Mr. Chairman, Colorado is the home of some of our Nation's most advanced aviation and weather research centers. You have been the guest and have been very helpful in support for the University Center for Atmospheric Research and the National Center for Atmospheric Research, both in Boulder, which have done outstanding work in weather detection and its relationship to air traffic management.

I would like to focus on two aviation technology issues that are relevant not only to the development of Denver's new airport, but to current air traffic management in Colorado and the Nation: weather detection and aircraft noise control.

Rapid and accurate weather detection is extremely important to Denver. Right now, Mr. Chairman, we are in the midst of Denver's thunderstorm season, when wind shear, especially microburst activity, is relatively frequent. While microbursts pose no threats to airliners at cruising altitude, they are extremely dangerous to jet aircraft flying close to the ground. Thanks to the work of UCAR and NCAR, especially John McCarthy and Walter Roberts, we have begun to develop flight procedures to assist pilots to navigate the fluctuating wind speeds caused by microbursts. We have already developed operational microburst detection systems. Of special note is the low-level wind shear and alert system and terminal Doppler systems, which provide pilots and air traffic controllers with real-time wind-shear warnings.

Both of these systems are available now. Their implementation would dramatically boost aviation safety and improve air traffic flow control. They should be installed at Stapleton, at Denver's new airport, and all major American airports. But surprisingly, Federal efforts to install the LLAWS and terminal Doppler systems, with all their safety and economic benefits, have been lacking.

For example, the administration has actually decided to slow down terminal Doppler radar procurement. Despite the fact that the FAA requested funding for 100 Doppler units in fiscal year 1987, the administration opted to request only 15 units. It is no wonder that Congress' investigative arm, the General Accounting Office, recently reported that the FAA's system for providing information on hazardous weather to pilots is slow and unreliable.

Mr. Chairman, we should be expediting the procurement of wind-shear detection technology. That includes the development of nationwide Doppler radar networks, known as Nexrad, which would provide controllers and pilots with regional wind-shear advisories. We should also continue research and development of new detection systems, especially airborne Doppler radar.

With this two-pronged approach—of procuring newly developed radar systems and researching mobile Doppler systems—we can make America's safe aviation system even safer. We reduce the threat of dangerous weather to our commercial and private air-

craft, a threat that claims 50 percent of the lives lost in aircraft accidents.

The other issue that I would like to raise briefly this morning is aircraft noise control. This is an absolutely critical issue for Denver and Adams County, whose communities which Congressman Brown and I represent a large part, whose communities bear the brunt of much of Stapleton's aircraft noise.

It is so important, in fact, that Denver and Adams County officials have concentrated on developing noise mitigation measures before designing the new airport east of the Rocky Mountain Arsenal.

I believe that the intensity of the debate over aircraft noise controls here in Denver signals a growing concern in major cities about balancing the need for expanded air transport services with an attractive quality of life. And that concern is not going to disappear without firm, sensible Government action to control aircraft noise.

Today's hearing will give us some insight into how we can render jet engines more efficient and less noisy.

Of course, new stage three airplanes are fitted with engines that are much quieter than stage two planes. We cannot expect air carriers to suddenly shoulder the tremendous cost of converting their predominantly stage two fleets into stage three fleets. Aircraft fleets composed entirely of stage three, even quieter planes, are a thing of the future. I hope the subcommittee will take the time today to examine less costly technologies for reducing aircraft engine noise.

While we pursue those technologies, we need a short-term solution to noise. And my proposal on this front would have little to do with new technology. Rather, it would rely on public-private cooperation to develop airport use restrictions that limit overall aircraft noise levels. This approach would require the help of local government authorties, the FAA, and major airlines.

Denver and Adams County officials have conducted painstaking negotiations to launch just such an effort. They have achieved a detailed agreement to curb noise levels and lay the groundwork for the development of Denver's new airport. Not only does this important agreement protect the quality of life for Coloradans in the metropolitan area, it would provide an impetus to develop quieter and more cost-effective jet engines, along with cheaper and better retrofit kits for older engines.

Unfortunately, the Denver-Adams County agreement has earned the wrath, rather than the praise, of the FAA. Earlier this month, the FAA notified Denver that the agreement was unreasonable, illegal, and more ominously "clearly would jeopardize existing and possible future airport grant funds."

Mr. Chairman, these are bold-faced threats and they are ill-founded, and they smack, it seems to me, of extortion. They undermine the cooperative spirit that is needed to expand America's air transport capacity in or near growing urban areas. They sacrifice the short-term strategy of curbing aircraft noise and, in so doing, threaten to erode the momentum for programs to develop quieter jet engines. They are, to be blunt, counterproductive.

I mention this matter because it points up the importance of sustaining the drive behind improvements in aviation technologies. During my years in the Congress, as you know, I have fought for adequate funding to develop new technologies to enhance aviation safety and economy. And it has always required a pitched battle to protect funds for this vital research and development effort. We appreciate your great efforts and leadership in this area to keep that research going.

You are aware of this problem, Mr. Chairman, and it will be discussed in today's hearing. But I think it bears repeating that we need to sustain a firm commitment to developing the new aviation technologies in air traffic control, aircraft design, weather detection, and so on, that enables us to make the best aviation system in the world even better and safer.

I thank you very much, Mr. Chairman, for asking me to come and testify this morning. We appreciate your interest and support. We had just 10 days ago representatives from the city of Denver and Stapleton testifying in front of the Congress, introduced by Congressman Brown, Congresswoman Schroeder, and myself on this aircraft noise issue. This issue is very clearly in the record. We are concerned and will continue to press for the kind of cooperation to, we think, begin to solve the problem.

Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Thank you, Mr. Wirth.

We invite you to sit with us during the remainder of the hearing this morning and give us the benefit of your knowledge of the local problems and the situation here.

Mr. Packard, do you have any questions?

Mr. PACKARD. I have none. Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Hank.

Mr. HANK BROWN. I have no questions.

Mr. WIRTH. Thank you very much, Mr. Chairman. We greatly appreciate you being here and we look forward to working with you. Thank you very much.

Mr. GEORGE BROWN. I might say that it occurs to me as an afterthought to my opening statement, where I had mentioned that one of the things that we are looking at in the design of new airports is the capability with the aircraft of the 21st century; it so happens that this committee, beginning this year, is giving consideration to the design of the next generation of space plane, the so-called national aerospace plane, which is intended to utilize existing airports to fly directly into space.

There are no airports in the United States tailored to that purpose today. And the Denver airport may be the first airport designed with the potential, at least, the next generation of transportation systems into space. It is an excellent possibility and one which I think the designers ought to give some consideration.

Our next witness this morning is Mr. George Doughty, director of aviation for the city and county of Denver. We welcome you here this morning, sir, and look forward to your testimony.

STATEMENT OF GEORGE DOUGHTY, DIRECTOR OF AVIATION, CITY AND COUNTY OF DENVER, STAPLETON AIRPORT

Mr. DOUGHTY. Good morning, Mr. Chairman, members of the committee. Let me add our welcome to Denver on behalf of the mayor and citizens of Denver. And, also, a special welcome to Stapleton International Airport. We are struggling to keep it operating and functioning as best we can under the press of being what we refer to at times as the most popular airport in the country. Maybe not popular with passengers, but certainly with airlines.

We are very pleased that you have chosen to hold these hearings in Denver. As everyone has mentioned previously, we have a unique opportunity here to incorporate major new technologies into the design of a new airport. And we intend to do so, at least as much as we can, from the standpoint of the city and county of Denver, who has the responsibility for providing this new facility.

Denver recognizes that it has an important role in the national air transportation system. And we realize that this role is the result of, to some extent, history, but also, to some extent, of our critical location in the middle of the United States, providing an excellent gateway to the western portion of the United States. And we intend to deal with that responsibility, and we are now attempting to, with the limited facilities we have. But we plan to also deal with it as we plan and develop the new airport.

The airport, although it has a responsibility to the national air transportation system, we also have responsibility to the community in which the airport serves; not only to provide an aviation facility, but to provide for a continued quality of life and to protect the citizens from unreasonable environmental impacts, particularly noise.

In our efforts to move ahead with development of a new airport, we have, as Congressman Wirth indicated, worked out several agreements with Adams County, who is our neighbor to the north and on whose land the new airport will ultimately be built; have tried to work out an agreement with them to move from various stages along the planning process, not only to provide for the new airport, but to also make the necessary improvements and expansions to Stapleton to get us by until the early 1990's when the new airport will be available.

The efforts that have been undertaken over the last 2 years are a departure from Denver's previous attitude with regard to airport facilities. We believe that now it is essential that Adams County be a part of this process and that all local communities affected by Stapleton and the new airport have a clear voice and understanding. And we work with them on a routine basis to ensure that the facility developed is advantageous to all of us and has as few negative impacts as possible.

We have entered into a recent agreement dealing with improvements at Stapleton. This agreement has been criticized by the FAA, criticized by the airlines. And we have worked with the FAA and with the airlines, also, over the last several weeks to try to deal with their concerns. We have all but eliminated, I believe, the concerns of the major airlines with regard to this agreement. They have committed to work with us on an accelerated basis to deal

with noise. And the FAA's concerns, I think we have addressed, if not all, certainly the majority of them. We are very pleased that we now have an agreement that we think is workable from everyone's perspective. And we can go ahead with two additional runways at Stapleton, as well as continue to plan for the new airport.

With regard to the new airport planning effort, that began a little less than a year ago. And we have an almost $3 million planning effort underway, with some of the top airport planning firms in the country. I do not think there is a major airport planning firm—there may be one or two—that is not somehow involved in either expansion of Stapleton or the new airport program.

This process has resulted in revised projections and forecasts for the new airport. The facility requirement needs have been established. And we have—we are now in the process of narrowing from 30 different airfield configuration concepts to—we are now down to seven airfield configurations. We have a site designated to begin development of the new airport. We have completed a site selection study and the selection process. Within a few months, we will have the airfield configuration in place. We will know exactly where the runways will be located and what the noise impact from those runways will be; what the flight tracks will look like from the airport, and just how efficient the facility—at least from an airfield standpoint—we can develop.

Following the planning process, which will be completed toward the end of this year and early next year, we will finish the environmental work, and begin the preliminary design work in 1987. If everything goes well, which is rare, but if everything does go as we anticipate, we will be able to begin construction maybe in the summer of 1988, certainly by 1989, and have the facility completed by 1993 or in the 1993-95 timeframe.

This process is being undertaken, again, as I mentioned, with the full cooperation of Adams County, and their full involvement, as well as the full cooperation and involvement of the FAA and the airlines in this process.

Again, we are very pleased that you took the opportunity to come here and discuss new technology with regard to airports. I would be most happy to answer any questions you may have with regard to our planning work on the airport.

Mr. GEORGE BROWN. Thank you, Mr. Doughty. You have given us a good idea of the scope of what you are planning here.

You did not mention your estimated cost figures. Shock us with them.

Mr. DOUGHTY. Well, we had some very—Mr. Chairman, some very preliminary costs that were developed about 6 months ago, in order for us to begin negotiating with the airlines, because they are very concerned about that item as well.

We feel that the initial phase of the airport could be constructed—those facilities that the city would be responsible for providing—for about $1.2 billion; plus the cost of land, which would be another $200 to $250 million.

The estimates are now being revised, and our revised forecast indicates that we may need more than five runways, which was the original concept provided initially; maybe a larger terminal complex; so that we may be looking at $1.5 million as an initial open-

ing day cost; plus about $200 or $300 million dollars of airline-provided facilities.

Mr. GEORGE BROWN. And you are anticipating, realistically, that you should get this construction completed and ready for operation in the 1993-95 timeframe?

Mr. DOUGHTY. We have set 1995 as our goal. We recognize that construction of the facility is probably—obviously, it is a major effort, but it is probably the least of our concerns, at this point, anyway. We need to deal with the environmental issues and the whole series of approvals that we have to go through. And assuming that they go very well, and they go along in track without lawsuits from neighboring jurisdictions—and I mentioned how we are trying to deal with that problem—and even lawsuits from individuals or other things that can prevent major projects of this nature from going forward; we think that 1993 to 1995 is a very reasonable date.

Mr. GEORGE BROWN. That is quicker than building a nuclear powerplant.

Mr. DOUGHTY. A much less problem, I believe, than a nuclear powerplant.

Mr. GEORGE BROWN. Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

Of that 1.7 billion that you are now estimating, how much of that are you anticipating coming from Federal sources?

Mr. DOUGHTY. Congressman, at this point, we have not made an estimate. Obviously, we would like as much Federal help as we could get. We are thinking in terms of certainly a minimum of $250 to $350 million over the 5- or 6-year construction period.

Mr. PACKARD. And the source of those Federal funds would be through——

Mr. DOUGHTY. We assume through a continuation of the AIP Program, if Congress so desires to do that.

Mr. PACKARD. In your written testimony—I presume that the city and county of Denver's written testimony came from your office—it indicates the sale of the present Stapleton property. That, of course, ties in with the agreement you have made, which I read with interest that you have agreed not to continue any aviation activities at Stapleton, with the new airport being built.

What portion of the new acquisition of the land, the land acquisition of your new site, would be covered by the sale of the existing site?

Mr. DOUGHTY. Well, part of the—there is an opportunity, obviously, there, and a problem. We have an agreement with both Adams County and the airlines that we would not continue, as you mentioned, the use of Stapleton as an airport. It is important to Adams County, obviously, for environmental and noise reasons. It is important to the airlines for marketing reasons. They want to prevent the Dallas-Love, Dallas-Fort Worth situation that they feel is a marketing problem for them.

This gives Denver an excellent opportunity to develop 4,700 acres of land for numerous purposes: future economic development, residential, all sorts of opportunity. There is obviously a problem of timing. We have to build and get into operation the new airport

before we begin to release—lease substantial portions of land for the old airport.

There have been estimates made of anywhere from $500 million to even approaching $1 billion, the value of the existing airport; because of its location, the infrastructure that is here. Let us assume that the $500 million level, as soon as we begin over time to release that land, then we would use that money to pay off the debt that has been incurred on the new airport. We may be able to generate a few hundred—up to $100 million of money from the sale of land that we could sell prior to the transition. But we really have not focused on how much we could generate before transition.

Mr. PACKARD. In your agreement, where you have agreed not to use Stapleton for any kind of aircraft, I would have to assume that you would move all general aviation to the new facility?

Mr. DOUGHTY. That is correct. We would anticipate at this point providing at least for itinerant general aviation at the new site. Based upon our obligations, of course, under Federal grant programs, we would provide whatever is required for all users at the facility.

We—although as a matter of policy, we want to do what we can to encourage the development of the three existing general aviation airports in the Denver area. And because of the location of the new airport, the proposed site, and the proximity of that site to Front Range, and we think we can continue to keep Front Range open and develop the new airport; it may be that Front Range would become the major general aviation facility, with some kind of limited access connector to the new airport; to separate general aviation traffic flow from scheduled air carrier operations.

Mr. PACKARD. Was the agreement to eliminate use of Stapleton—of existing Stapleton, one of the areas of disagreement with FAA?

Mr. DOUGHTY. No.

Mr. PACKARD. Would you outline for me the concerns the FAA has expressed?

Mr. DOUGHTY. There are two agreements that have been reached between Adams County and Denver. One was a memorandum of understanding, which was reached over a year ago with Adams County. There were no serious objections to that agreement from the FAA or even the airlines. And that is the agreement that called for the elimination of Stapleton, the elimination of aircraft operations at Stapleton. And this has been done—the FAA has concurred in this, provided, of course, the revenue from the sale of the old facility is used for the development of a new facility. So there is some precedent for phasing out of old airports, if new capacity is being provided at new airports.

So the FAA did not object to that.

The most recent agreement dealt with some noise mitigation measures which would be taken at Stapleton by Denver, and certainly which the FAA would need to at least cooperate in order to implement, prior to construction of additional runways at Stapleton.

The FAA's principal objection was that the—some of the provisions implied, or attempted, in their view, to force the FAA to cooperate, rather than leaving their decisions, particularly with regard

to air traffic—which are strictly their purview—without leaving them the option of making that decision independently.

We have corrected most of those issues, we think, except for one or two which we are working on even today prior to final ratification by the Denver City Council. So once they are resolved, I think we are in a pretty good position.

There were a few other—I'm trying to recall—more minor concerns, but basically what they felt was an instrusion by Denver into their exclusive area, which is air traffic. We do not want to do that any more than we would like them intruding into our exclusive area of airport proprietor rights.

Mr. PACKARD. What do you plan to do on the new facility with regard to noise levels in comparison to what now exists at Stapleton?

Mr. DOUGHTY. Well, Congressman, obviously one of the major things we can do is acquire more land, to assure that land use in the most noise-intense areas remains compatible with airport operations. As you know, at Stapleton we have a number of residential areas that are in up to the 75 LDN noise contour, which is an extremely high noise level.

We certainly will be acquiring all land within the 70 LDN and probably would acquire development rights or other interests within all land in the 65 LDN, which is the Federal standard for residential development. We feel that would be—that will go a long way to preventing noise problems.

Unfortunately, there is noise at Denver well outside the 65 LDN because of the way aircraft are vectored in the area; because of the fact that Denver's altitude— elevation and the altitude makes aircraft climb slower, particularly in hot weather. So there are some unique problems that other airports do not have. And through a cooperative process between the FAA, the airlines, and the airport neighbors, we think we can define flight tracks in such a way that we know exactly where these airplanes are going to fly in their normal operations at the airport, and they will not be flying over established residential areas.

Mr. PACKARD. So you do not anticipate that you will simply be transferring a set of problems from one neighborhood to another neighborhood by moving the airport?

Mr. DOUGHTY. We certainly do not. And we intend to do very careful planning in that area. It is an area that is of extreme concern to Adams County. And as we move along each step of the way, they are going to be very sensitive to those issues.

Mr. PACKARD. I would like to ask other questions, Mr. Chairman, but I have exceeded my 5-minute limit, and I do apologize for that. I conclude my questioning.

Mr. GEORGE BROWN. Hank, any questions?

Mr. HANK BROWN. Thank you, Mr. Chairman.

Denver was probably one of the most progressive cities in the Nation in the 1930's and 1940's. Those of us who have called it home for most of our lives would not have described it as the most progressive city in the 1950's, 1960's, or 1970's. And I think the changes you have made in the past few years in planning is a marked shift back to that era when it was a very progressive city. And I want to extend my commendations to the city for its willing-

ness to work with Adams County in its long-range view of this airport problem, which I think is going to be a great blessing for the State.

I just had a couple of questions that I would like to share with you.

The—you indicated that the value of Stapleton could run from $500 million to a billion dollars. Obviously, when we ask you to put a figure on that, we are asking you to speculate at some point in the future. But is Denver committed to plow back the entire value of Stapleton into the new airport, or is it possible that some of the value of the airport would revert back to the city of Denver and not be used for aviation?

Mr. DOUGHTY. Congressman, you are asking a question that is somewhat outside of my realm, but let me tell you what I do know about that.

Certainly, the money that was contributed by the FAA, the Federal Government in the development of Stapleton, would obviously be transferred to the new airport. We have a bond ordinance that is—master bond ordinance in Denver, dealing with the revenue bonds that were sold not only for land acquisition at the new airport, but for improvements to Stapleton that require that airport funds remain within the airport account and cannot be transferred to the general fund.

It may be possible to make a case that there are certain assets that were contributed by Denver, some of the land in the past and certain other assets, that could be transferred back to the general fund. But by and large, the total receipts from the sale, or lease, or whatever is done with Stapleton or various parts of it would be used to pay off, first of all, Stapleton debt; and then, second, debt at the new airport.

Mr. HANK BROWN. I take it that the improvements, the major improvements that have been paid for over the years are in the account that would require their proceeds to be used for airport purposes?

Mr. DOUGHTY. That is correct.

Mr. HANK BROWN. What happens if Adams County turns down the annexation? What if they vote against—what are contingencies here?

Mr. DOUGHTY. Well, that is an alternative that we do not like to think about a lot. But we are probably stuck in that situation with the continued use of Stapleton for the remainder of this century. There is a provision in the Adams County agreement that deals with the shutting down of the two additional runways, assuming we construct the north-south and east-west expansion runways at Stapleton. Those runways would, at least under the agreement, be closed and cease operating in the year 2000.

We really do not have much flexibility if we cannot construct the airport on land that is currently within Adams County. Quite frankly, politically it is very difficult for Denver to propose to build an airport on land that would not become a part of Denver. It is a policy decision probably for elected officials later to make. But we think that this new airport is such an important economic asset to the region, and it can be developed without serious environmental problems to Adams County, that we feel fairly confident that we

will be able to convince the voters of Adams County that this will be good for them as well.

Mr. HANK BROWN. I notice in your planning that, obviously, the new airport is dramatically larger than the current one.

Can you give us an idea of what arrangements have been made to provide for extra land at the airport, to provide unknown factors or new developments or, for example, landing craft that might transit to space? What extra buffer have you got planned for this new facility that would take care of unknown future developments?

Mr. DOUGHTY. We have designated a site area which encompasses about 60 square miles. We anticipate that the airport on opening day would utilize approximately something less than 20 square miles. We probably would acquire in the neighborhood of 35 to 40 square miles to provide for the airport as it would be developed in the year 2020.

To some extent, and this gets into some very technical problems with planning, we anticipate that the current rules that are in effect, dealing with separation of runways and other things, that require—today probably require more land than would actually be needed at the time these additional runways would be provided because of improved technology. We are certainly providing for a worst case situation. Let us assume that the rules do not change substantially. Then we would be able to build an airport to accommodate our needs in 2020.

New technology aircraft are something that will be part of the detailed planning process. But we at this point anticipate that most of their needs can be accomplished by widening or lengthening of runways. And we even feel that it may be necessary to provide one runway in excess of 16,000 feet in order to assure nonstop operations to Europe and to the Far East from Denver; considering the altitude of Denver, a runway of that length may be necessary.

So we feel very confident that we will be able to provide for the technology of the future and to accommodate Denver's need through 2020. And once you get much passed the year 2000, it becomes rather difficult to anticipate, but we feel fairly confident at this point.

Mr. HANK BROWN. That might apply to the rest of us, personally, to.

One last question. What measures have you taken, or what assurances have you gotten from Adams County that the surrounding zoning will be one that is compatible with the airport use?

Mr. DOUGHTY. The memorandum of understanding with Adams County provides that Adams County will take the necessary measures to deal with the land use problem, In areas where we will not be able to or will choose not to, by mutual agreement with Adams County, not to acquire.

At this point, it is a memorandum of understanding. There will be additional intergovernmental agreements that will deal with that issue that we will put in place prior to developing the new airport. We do not want to get into a situation as Dallas-Fort Worth did, where they could have acquired some land that later became developed for residential. So we want to assure that that does not occur.

Thank you. And thank you, Mr. Chairman.

Mr. GEORGE BROWN. Let me add just one additional question, Mr. Doughty.

A portion of the funding for the new airport is going to have to come from city or county issued revenue bonds. These are ordinarily the tax-exempt municipal bonds.

Mr. DOUGHTY. That is correct.

Mr. GEORGE BROWN. You do not have to be concerned about the changes in the Federal law with regard to tax exemptions for industrial development bonds or anything like that?

Mr. DOUGHTY. We have been very active with our industry group in assuring that the—trying to assure that the new tax law does not limit our ability to use tax-exempt bonds for this purpose. Right now, both versions protect us fairly well. I think the Senate version does a little bit better job than the House version with regard to tax-exempt bonds. We are very concerned about it. We think it is something that is necessary if we are going to be able to move ahead quickly with the new airport.

Mr. GEORGE BROWN. Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

Simply to help me throughout the day to understand the organization—the governmental organizations that deal with this problem and the issue, the city of Denver and the county of Denver, are they—are they run by the same people?

Mr. DOUGHTY. The city and county of Denver is one political entity.

Mr. PACKARD. One political entity. Somewhat like San Francisco, you have a city council that runs both the county and the city?

Mr. DOUGHTY. Right.

Mr. PACKARD. So you are not dealing with two entities there?

Mr. DOUGHTY. No.

Mr. PACKARD. Is there an airport district that is involved in Stapleton or that will be involved in the new airport, or is it under the jurisdiction of the elected officials of the city-county?

Mr. DOUGHTY. It is solely under the jurisdiction of the city and county of Denver. It is currently a division of the Department of Public Works of the city and county of Denver.

Mr. PACKARD. The county of Adams would be—would the expansion of existing Stapleton involve the county of Adam as planned; and each of the other sites for new location involves Adams County, is that correct?

Mr. DOUGHTY. That is correct. One runway is solely—an expansion runway is solely within Adams County. The second one is about one-third in Adams County. They are planning on the Rocky Mountain Arsenal, which is a Federal——

Mr. PACKARD. So every plan that is being considered involves Adams County?

Mr. DOUGHTY. That is correct.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Thank you, Mr. Packard.

And thank you very much, Mr. Doughty, for your excellent testimony.

Our next witness will be Dr. Raymond S. Colladay, who is Associate Administrator for the Office of Aeronautics and Space Technology, with NASA. I know, Dr. Colladay, that you are always brief

and to the point. But if you have an extensive statement, would you try to summarize it somewhat so that we can complete our work today in a timely fashion.

STATEMENT OF DR. RAYMOND S. COLLADAY, ASSOCIATE ADMINISTRATOR, OFFICE OF AERONAUTICS AND SPACE TECHNOLOGY, NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Dr. COLLADAY. Thank you, Mr. Chairman, Mr. Packard, and Mr. Brown.

I do have a statement for the record. I do not intend to read it.

Mr. GEORGE BROWN. Without objection, it will be included in full.

Dr. COLLADAY. Thank you.

I would like to take this opportunity to summarize some key issues and then respond to questions.

First, let me commend you for the leadership shown in holding this hearing, and also the site selection, which naturally is an appropriate one, given the subject. But on another point, nothing can beat coming to the Mile High City to get away from the heat and humidity of Washington.

The importance of looking into future aircraft requirements for meeting operational aspects for new airports is terribly important. We do not have many chances come along to do it right. We can look at this as the last airport of the 20th century or the first airport for the 21st century. It will be operational long after every airplane flying today is gone.

So it is terribly important for us to look into the future. This business of forecasting the future is a risky one. We have many examples where we forecast the future by extrapolating the present or the current trends. And if we do that, the answer will be totally wrong in this case. There is enough evidence, in the form of what deregulation has done and the technology that is on the board now that we are working, to suggest that the future is going to be quite different than what an extrapolated past would lead us to believe.

I wonder if we really recognize the change that we are going to see in future aircraft as we prepare for the decade of the nineties and the 21st century. We only need to look at the airplanes on the drawing board. In fact, those that have current hardware under development and, in some cases, even aircraft flying in prototype form today, to recognize that there are truly revolutionary advances to be had.

To be sure that evolutionary advances will continue—if I could have the first chart? Mr. Nixon, why don't you turn that to the side and use the side screen so it is not pointed at—tilt it down. That's better.

Of course, there will be evolutionary advances in current aircraft or aircraft that look very similar to those that are flying today, like this subsonic transport aircraft (fig. 1) that is powered by propfans or high-speed propellers, and has high-aspect ratio, supercritical wings, and composite structure. The economic benefits of fuel savings generated from these types of aircraft will certainly support the growth in typical subsonic transports in the future.

But I would like to turn to what I would classify as the evolutionary, or revolutionary advances in future aircraft. The first one

being the tilt rotor (fig. 2), which we have worked extensively with the Army in a prototype form called the XV-15. It is the basis for the new military development of the V-22 Osprey aircraft. It takes off like a helicopter, but flies at typical turboprop speeds without the noise and the vibration typically encountered in helicopters. It is very likely that we will see a commercial version following the military applications. To that end, we have joined with the Department of Defense and the FAA in doing various system studies for civil applications for this airplane.

On a similar note, but able to fly at still higher speeds, figure 3 shows the concept of what we call the X-wing. Many of you have seen the forward swept wing that we call our X-29 experimental aircraft. This is both a forward swept wing and a typical aft swept wing. It, too, takes off like a helicopter with the rotor in rotation up to forward speed of approximately 200 miles per hour, and it converts to a fixed-wing aircraft, flying forward up to 500 miles per hour, with the rotor locked in position. The X-wing can serve remote areas and feed major hub airports with vertical landing-and-takeoff capability, and as high a speed as our current subsonic transport aircraft.

Mr. GEORGE BROWN. You mean the rotor becomes a wing?

Dr. COLLADAY. That is correct. It takes off like a helicopter, with the rotor rotating, and goes through a transition with the rotor locked in place; and it flies like a standard fixed-wing aircraft.

It has been 24 years, going to still higher speed, since the Anglo-French agreement on the supersonic transport, the Concorde, was signed. The Concorde, has been in service, as we all know, for 10 years now. Much has been learned about how to build and operate an economical supersonic transport. I am not suggesting that the United States is ready to do that, but certainly the research is on the drawing board to develop a much more efficient and economical high-speed supersonic transport.

Figure 4 shows a typical example of what such a transport might look like. It can carry the number of passengers of a 747, at three times the speed of sound. That is productivity—number of passengers and speed and the degree to which you can utilize the equipment, operating it much like a 737 is operated in the Northeast corridor. The trick to an economical and highly utilized supersonic transport is quick turnaround getting the airplane back in the air, even though there are long distances; in this case, trans-oceanic and transcontinental flights.

The Concorde spends a good deal of its time on the ground and is not making any money in that condition.

Now I have gone from vertical takeoff and landing in very slow speed all the way to mach 3. And as you pointed out, Mr. Brown, there is still something else on the horizon at still higher speed yet. It has many names. In fact, it has as many names as are partners in the program. It is called the National Aero-Space Plane Program, that is underway, currently sponsored by NASA and the Department of Defense.

This airplane could fly at hypersonic speeds, with trans-Pacific range, flying from Denver to Tokyo in less than 2 hours, and skimming on the outer edges of the atmosphere, and may even accelerate into space. It is the first, truly endo-exo atmospheric vehicle

that could make routine, round-the-world travel economical. We are developing the technology to put that in place, and should see an experimental airplane flying in the first part of the 1990's, with commercial and military applications and possible launch vehicles somewhat downstream of that, but not so far downstream that in planning a new airport one should not consider that type of vehicle.

The key to the future in all of these aircraft configurations is diversity and flexibility. An airport of the 21st century must be able to handle a diverse mix of aircraft, from subsonic transports that are both propeller-driven and fan-jet-powered, smaller commuter aircraft, general aviation, helicopters, short takeoff and landing vehicles that can operate off short runways in the outlying areas and then feed the central hub airports for the transcontinental flights, to jet-powered vertical takeoff and landing for even higher speed, inner city and remote area service; the supersonic transport; and, finally, a hypersonic transport.

All of these types of vehicles must be considered in the mix of aircraft that a future airport will have to service.

In the 1950's, we proved the threshold required a dependability in aircraft travel. In the 1960's, it was jet power; in the 1970's, the hi-bypass ratio turbofans enabled the wide-bodies. In the 1980's, the playing field has changed. In many respects, it has been the ingredient for being able to move forward in this future of diversity and flexibility. Deregulation and technology of the 1980's are combining to change the way we think about aviation and air travel in the 1990's and in the 21st century.

It does not do any good to have the airplanes that can serve our future, no matter what their need, whether they be rural, hard-to-reach areas, or inner city traffic, or transcontinental, or transoceanic, if our operations, airports and air traffic control systems constrain those aircraft to operate in the 1970–80 mode of operation.

It is terribly exciting to me to see a chance to develop an airport from a clean sheet of paper. It is up to all of us to make sure that we help in the forecasting of what kind of airplanes such an airport will have to serve.

Thank you, Mr. Chairman. I would be very happy to answer questions.

Mr. GEORGE BROWN. Thank you very much, Dr. Colladay.

Mr. Packard, do you have any questions?

Mr. PACKARD. Yes, Mr. Chairman.

Your testimony, of course, is very fascinating and interesting.

In developing an airport that will not proscribe and restrain the minds and ingenuity of man in developing these kind of craft for the future, what kind of changes would be required from existing airports that we—the most technologically advanced airports that we now have? What additional changes would be required to accommodate this mix of new technology in space craft and aircraft that we are looking at? And do we have the technology—has there been research done to determine what kind of an airport would be necessary in comparison to existing airports to accommodate it?

Dr. COLLADAY. Well, Mr. Packard, there has been a great deal of research, not much of it within the NASA program. As you know,

we concentrate primarily on the aircraft side. But we do have a portion of our program directed at terminal area operations and weather prediction, which you will hear more about this morning; and how to make the most of a flexible-based fleet of aircraft so that the advantages derived from high speed, point-to-point are not totally erased in the terminal area, taking a long time to get into the landing pattern and to the airport.

We are looking at things like high-speed turn offs and runway construction for safe operation; 4-D navigation—by that, I mean arriving at a particular place in space and in time, so that aircraft arriving in the terminal area can fit into the approach pattern as efficiently as possible.

A number of things on that scale need to be worked out in order to make sure that we exploit the advantages that the airplane of the future is providing.

Mr. PACKARD. One of the problems with the Concorde is that it is terribly noisy; thus, noise barriers prevent it from landing at very many airports, certainly here in the United States.

Will these new pieces of equipment be struggling with the same kinds of problems, or will it be limited in terms of its usefulness because of noise factors?

Dr. COLLADAY. Let me first answer that anecdotally.

One only needs to look at the hi-bypass ratio fan-jet-powered aircraft, the most recent introduced into service, the DC-9 that grew out of the NASA Re-Fan Program for quiet engine research; the 767 and 757 that were developed on energy-efficient engine technology in our program. One only needs to look at those and the performance of those airplanes to recognize that one does not need to pay the price of performance to get a good neighbor airplane that is quiet.

We are developing technology that is both good from an economic sense in performance, as well as lowering the overall threshold of noise in the operating aircraft that we are developing, or developing the technology for. That is particularly true on any future supersonic transport.

We think that the technology has come along in the 24 years since the Concorde was essentially frozen as a design, to have an airplane that is quiet enough to fly within the existing noise regulations, and even quieter, given variable cycle engines and various airframe noise control measures. So I do not expect that a supersonic transport will be noisy in the sense that the Concorde is today. You will not see one introduced into service if it is. The design constraint that we have on the technology is that it has to be quieter than today's airplanes.

Mr. PACKARD. One of the problems with airports, the busyness of airports, certainly here at Stapleton, is being able to—the requirement to space takeoffs at certain distances because of the vortex problem. What kind of progress have we made in research in that area, or are we pretty well at the end of the line on that? Are we finding no solution to that problem?

Dr. COLLADAY. Well, we declared the end of the line of building hardware and testing it, and going out and building more hardware, and taking a shotgun approach to a very sophisticated and complex problem. But, in my opinion, we have not begun to really

solve the problem. And I think it will yield to a technological solution. It requires prediction and computation of the complex, vortex flows off the lifting surfaces. And I think when we are able to do that, and with the new numerical aerodynamic simulation capability we have now operational as of a few days ago, we have the ability to predict the vortex pattern off airplanes and high-lift devices. When we understand that, I think we will be able to go a long way toward the amelioration of that problem. It is critical that we find a solution to it because it quickly becomes the pacing item—no pun intended—to bring the aircraft in on a tight landing pattern.

Mr. PACKARD. One last question, if I may, Mr. Chairman.

Any hypersonic aircraft or supersonic aircraft—well, hypersonic aircraft, will require, as I understand the technology, liquid hydrogen as a fuel. Ground resources to provide for that, will that create any problem for airports and airport management?

Dr. COLLADAY. Well, it is a logistics problem that needs to be addressed, but not by any means an insurmountable problem. We know how to handle hydrogen. It can be piped around an airport underground in a safe and effective way. It is not clear at this time what the fuel of choice for a hypersonic aircraft would be. If it is an airplane that flies above mach 5, then hydrogen is necessary as a fuel. And in that case, an airport would have to develop storage and transport mechanisms to be able to routinely fuel airplanes on hydrogen. But that is doable.

Mr. PACKARD. Thank you, Dr. Colladay.

Mr. GEORGE BROWN. Hank.

Mr. HANK BROWN. Thank you, Mr. Chairman.

Have you had an opportunity to study the proposed patterns for the new airport here in Denver?

Dr. COLLADAY. No, sir; I have not.

Mr. HANK BROWN. The purpose of my inquiry was to determine whether or not a Concorde or a plane with similar noise level problems could be landed without major noise disruptions to the community under the new designs. Perhaps you have a guideline we ought to look at in terms of buffer area required for a Concorde noise level?

Dr. COLLADAY. I would be happy to look into that for you, sir, and give you a more considered opinion. I have not looked into it.

Mr. HANK BROWN. Thank you. I would appreciate having anything you have in that area.

[The requested material follows:]

The guideline we would recommend to use for determining the appropriate noise buffer areas required for operations at the new Denver airport is the FAA's Federal Aviation Regulation (FAR), Part 150—Airport Noise Compatibility Planning Program. It establishes the Integrated Noise Model (INM) as the standard noise-modeling methodology, identifies the land uses that are normally compatible with various levels of airport noise, and provides for voluntary development of Noise Exposure Maps and Noise Compatibility Programs by airport operators and their submission to the FAA for approval.

The FAA Integrated Noise Model has been adopted as the standard noise model to assure uniformity and comparability of Airport Noise Exposure Maps. The INM is a series of computational modules which will produce airport noise exposure contours and can calculate noise exposure at specific points in the airport vicinity. A standard data base of aircraft noise and performance for sixty-six aircraft types, including the Concorde, accompanies the model. The INM is designed for use on mainframe computers and over one hundred magnetic tapes have been sent to various

companies and organizations for use on large computer systems. It is now available on diskettes for use on the IBM XT personal computer. Additional information on the INM is available from Noise Technology Branch, AEE-120, Office of Environment and Energy, Federal Aviation Administration.

Do you anticipate that the hypersonic planes will have a noise level less than the Concorde? Is that——

Dr. COLLADAY. Well, certainly with the supersonic transport, where we can take off with the engine configured for efficient subsonic flight, we expect that noise levels would be considerably below the Concorde. The Concorde has a takeoff with full afterburner. It is more the takeoff noise than the approach noise, although at approach it is a pretty noisy airplane, too.

I am not certain yet about the hypersonic transport. There is a problem that needs to be addressed with the sonic boom, which flying at 150,000 feet over land is not a terribly serious problem, but you have to land and take off. And how you do that over land is an area that we will be exploring, certainly in the experimental vehicle.

I believe that the technology will be in place to have a good shot at making it a quieter airplane than the Concorde, but it is really too early to tell for the hypersonic transport. I feel safe in predicting a modern technology, supersonic transport would be quiet. But I would rather wait a little bit longer, as we develop the technology, to see how friendly a neighbor a hypersonic transport might be.

Mr. HANK BROWN. Is there any estimate at this point as to what altitude or how high the hypersonic planes—how far it goes or how high it is when it reaches the sound, speed of sound?

Dr. COLLADAY. Well, it would go transonic at 40,000 feet. So it is low enough altitude that we would have to be concerned about sonic boom. But there are things you can do to control the overpressure, by the shape of the airplane, the size of the vehicle. There are many many factors that affect the overpressure or sonic boom created by a plane breaking the sound barrier. And we know how to now reduce it to imperceptible levels. It is a matter of managing the flight profile and the shape of the airplane in such a way to minimize that ground overpressure.

Mr. HANK BROWN. Thank you.

Mr. GEORGE BROWN. Dr. Colladay, if and when we move into this next generation of supersonic or hypersonic aircraft, are we going to see a replay of the environmental debate that occurred 10 or 15 years ago with regard to the first SST proposals; the problem of impacting the ozone layer, and various things of that sort?

Dr. COLLADAY. I don't believe so. But, then, Mr. Chairman, it is hard to predict the emotional arguments. Some of them may still be carryovers from what I call emotional rather than substantive arguments. That does not mean to suggest that our original entry into the supersonic transport, with the U.S. version, was environmentally benign. It had some problems. That is one of the reasons why we didn't go ahead and build it. With an airplane of the future that we now think we will be in a position to build, or when the technology is in place to do that, it should not be a problem from the sonic boom standpoint. Environmentally, I think the upper atmosphere impact has been proven to be minimum. And if I could point out with the hypersonic transport and hydrogen fuel,

both those problems are even less severe because you fly at a higher altitude, so the sonic boom is not felt as significantly. And with hydrogen fuel, it is a clean burning fuel, and does not produce the hydrocarbon exhaust that would impact the upper atmosphere. There still would be——

Mr. GEORGE BROWN. There are going to be people who will say that it will produce heavy rainstorms.

Dr. COLLADAY. Well, I put that in the category of the emotional arguments, sir. I do not believe it will.

Mr. GEORGE BROWN. Any further questions?

Excellent testimony. Thank you very much, Dr. Colladay. That was very stimulating.

[The prepared statement of Dr. Colladay follows:]

NASA
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July 28, 1986

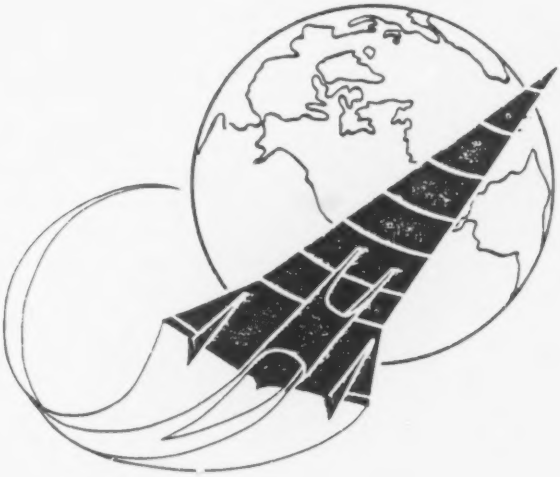
Subcommittee on Transportation, Aviation and Materials
Committee on Science and Technology

House of Representatives

Hearing on Airport Technology
Denver, Colorado

Statement by:

RAYMOND S. COLLADAY
Associate Administrator
Office of Aeronautics and
Space Technology



99th Congress

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PRESENTED BY WITNESS

JULY 28, 1986

STATEMENT

OF

Dr. Raymond S. Colladay
Associate Administrator for
Aeronautics and Space Technology
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

before the

Subcommittee on Transportation, Aviation and Materials
Committee on Science and Technology
House of Representatives

Mr. Chairman and Members of the Subcommittee:

I welcome this opportunity to appear before you to discuss NASA's views on the important issues that affect planning for a totally new airport in Denver. Considering the limited number of opportunities to develop new major airports, it is essential that very serious consideration be given to the role of that airport in our future air transportation system, the impact of future aircraft and air traffic control technology developments, and the effective integration of the airport with the surrounding community.

As we all recognize, it is extremely difficult to predict the future, particularly for aviation, where technology continues to move forward very rapidly. With this caveat let me share with you NASA's vision for the future of aviation, particularly as it may relate to the development of the new Denver airport. This vision of the future is based on our knowledge of on-going and planned technology developments.

The emerging technologies over the next decade or two will provide the basis for major improvements in the air transportation system whether they are reflected in derivative aircraft, conventional new aircraft, or revolutionary new designs with significant new capabilities. Technology developments will also allow for significant improvements in aircraft and air traffic control capabilities for the precise 4-dimensional navigation and guidance that will be required to handle the substantial growth in air traffic that is expected to occur in the future. The almost tenfold increase in passenger miles over the last 20 years, brought about by the introduction of the jet era, translates into an average 12% annual growth rate. While this level of growth is not expected to continue, conservative forecasters predict a continued growth rate averaging around 5%, which would

produce a 2.6 factor increase in passenger miles over the next 20 years. In order to accommodate this growth, some current market analyses project that the number of aircraft in operation will triple by the end of the century, resulting in the addition of 4,000 new aircraft in the next 15 years. Most of the demand will probably continue to be in the domestic size and range classes, but a substantial amount will be in the larger over-ocean category. The projected increases in population, commerce, and tourism are expected to result in significant increases in long-distance transoceanic travel between developed and developing countries. The opportunities for increased travel appear particularly strong across the Pacific, where the development of economical high-speed travel would provide support to rapid increases in trade. With this potential for a substantial growth in air travel in mind, let us look at the possibilities for new aircraft to provide the service.

Future Aircraft

In projecting the character of future aircraft, one should briefly review the past. Following World War II, aircraft designers provided a series of ever-improving vehicles which, when compared with the DC-3, the work horse of the World War II period, provided: speed increases by a factor of 3, range increases by a factor of 6, payload increases by a factor of 10, and cost per seat mile reductions by a factor of 3. The evolution of aircraft has been characterized by a series of technical levels or plateaus that extend over a period of years. Each level has been characterized by an aircraft configuration that is gradually improved by a series of relatively small refinements without any major conceptual change. Then the stimuli of new technology in a number of disciplines and changing design requirements are periodically combined synergistically to produce an aircraft of substantially higher levels of performance.

Aeronautical opportunities are known today which, if actively pursued, could establish a new technology level or plateau of efficiency or even entirely new vehicle classes. Aircraft with these advanced capabilities, if available around the turn of the century, will without a doubt, provide the kind of revolution that resulted from the introduction of the first jet transport over 30 years ago. We see no technological barrier to the development of these vehicles if the research and technology momentum that has given life to the preceding families of aircraft is continued, if the market is perceived, and if the development resources are available.

In an evolutionary sense, the aircraft manufacturers appear poised to introduce new subsonic transport aircraft (Fig. 1) which will incorporate major technology advances in

aerodynamics, structures, propulsion, and systems. The most apparent change to the vehicle may well be the introduction of new propulsion systems based on NASA and industry developments in advanced turboprop technology. General Electric is currently testing a gearless, counter-rotating Unducted Fan advanced turboprop engine, and Pratt and Whitney/Allison/Hamilton Standard are developing an advanced, geared, counter-rotating turboprop engine. Both Boeing and Douglas are currently investigating aircraft designs using these propulsion systems. These designs offer substantial improvements in fuel efficiency relative to current jet transports, particularly those that were initially introduced 10-20 years ago. These same technology advances are also applicable to future generations of improved general aviation or commuter aircraft and larger subsonic transport aircraft. These new transport aircraft, as dramatic as their efficiency and economic improvements may be, constitute evolutionary improvements in air transportation that represent more of business as usual in terms of airport operations.

In a more revolutionary sense, technology developments are also underway that will allow for the introduction of new aircraft with greatly expanded capabilities: vertical or short takeoff and landing (V/STOL) aircraft, high speed rotorcraft, and supersonic or hypersonic cruise aircraft. These aircraft will require particular consideration in terms of airport and air traffic control requirements in order to take maximum advantage of their special capabilities.

Because of their unique capability to serve the high altitude, short runway, difficult access airports near Denver, short takeoff and landing (STOL) aircraft like the deHavilland DHC-7 turboprop aircraft are already operating in and out of the current Denver airport. In the early 1970's, work was initiated by NASA and the DoD to develop the technology base for turbofan powered-lift that would enable the design of civil and military STOL transports that would be safe, quiet, and efficient. This technology was developed and tested on the NASA augmentor wing research aircraft and the Quiet Short-Haul Research Aircraft (QSRA) which used over-the-wing blowing. This technology was also applied on the Boeing YC-14 and Douglas YC-15 prototype transports and is now being incorporated in the Douglas C-17 military transport. This technology is ready to be applied to future civil STOL transport aircraft if a sufficient market develops.

Recently, the success of NASA's V/STOL technology efforts has led directly to the development of the V-22 Osprey tilt rotor aircraft by the DoD. The technology for the V-22 is based on over 20 years of NASA and Army research on the tilt rotor concept for high-speed rotorcraft flight,

culminating in proof-of-concept flight testing with the XV-15 Tilt Rotor Research Aircraft. The 900 aircraft V-22 program marks the introduction of a revolutionary aircraft concept into the nation's military fleet. The experience resulting from the V-22 development will provide the basis for possible early transfer of the capability to civil application. The opportunity for large-scale inter-city and inter-regional transportation using civil tilt rotor transports (Fig. 2) with the speed and comfort of a turboprop aircraft has led to a joint agreement between NASA, FAA, and DoD to study and quantify the civil technology benefits that can be derived from the V-22 tilt rotor program. Civil derivatives of the V-22 could provide an early opportunity for the development of 20- to 70-passenger tilt rotor transports.

NASA is currently involved with the Defense Advanced Research Projects Agency in the development of technology critical to the successful design and flight test of a new X-wing rotor on the NASA/Army Rotor Systems Research Aircraft. The X-wing rotor has four extremely stiff blades that can be transformed during flight into an X-shaped fixed wing configuration. The rotor operates in a spinning mode as a helicopter rotor for vertical takeoff and landing, hover, or during low speed operation. At a speed of about 200 miles per hour, the rotor is stopped and locked in place, providing fixed-wing lift for much higher speeds than conventional helicopters. In its full application to an advanced military aircraft, speeds of 500 miles per hour are envisioned. Although the integration and near term application of this technology will be for military use, the technology advances also have broad application to future high-speed civil X-wing rotorcraft (Fig. 3).

It has been 24 years since the 1962 Anglo-French agreement to build the Concorde was signed. On January 21st of this year, the Concorde fleet completed 10 years of active commercial service. Ten years is long enough for the novelty to have worn off, and it is evident that there is a steady demand for high speed transportation, even at premium fares. During the last 24 years, there have been significant advances in technology in all the disciplines of aerodynamics, propulsion, structures, and systems that are applicable to a new generation of high speed transport aircraft. These aircraft could take the form of new supersonic transports or Orient Express hypersonic transports.

Design studies conducted by major aircraft manufacturers indicate that an advanced technology supersonic transport (Fig. 4) could economically carry a comparable number of passengers over transpacific ranges (5000 to 6000 nautical miles) at more than three times the speed (and hence the productivity) of subsonic vehicles. Operating cost

estimates suggest that little, if any, surcharge over current fares would be required. These projected improvements are based on aerodynamics research indicating that a new wing design could achieve major reductions in cruise drag; propulsion technology advances, most of which have evolved from the subsonic quest for improved fuel efficiency; new materials for reduced airframe and engine weight; and flight control systems that allow more fuel efficient flight profiles and two-man crew operation. Other factors critical to the success of a new supersonic transport which require additional technology development are methods to reduce the takeoff and landing noise, sonic boom reduction, and overcoming the high development costs.

Exciting opportunities are evolving for a revolutionary leap in U.S. hypersonic/transatmospheric flight capability that could reshape military and civil aviation near the turn of the century. Pursuing recent advances in aeronautics and space technologies will enable an entirely new class of aerospace vehicles, powered by airbreathing propulsion, that will have vastly superior performance relative to anything flying today. Conceptually, these vehicles will operate from conventional airport runways and fly at speeds between five and twenty-five times the speed of sound, to the edge of the earth's atmosphere or even accelerate into space, using airbreathing engines fueled by liquid hydrogen. The extreme altitude and speed capability of this technology could make high speed military aircraft nearly invulnerable to attack and initial indications are that such transatmospheric vehicles could reduce the cost of delivering payloads into orbit. Technology development and verification in many critical technology areas are required including airbreathing propulsion with efficient operation from takeoff through hypersonic speeds; lightweight engine and airframe structures to withstand repeated exposure to extreme heating loads; and highly integrated airframe and propulsion configurations. A commercial hypersonic transport (Fig. 5) developed using this technology could provide access from the continental U.S. to the Pacific nations in less than 2 hours.

Airport Operations

NASA research, while primarily oriented toward vehicle characteristics, airborne systems, and cockpit human factors, includes a number of efforts directed at aircraft operations in the terminal area and on the runway. This research bears importantly on both airport safety and capacity. In the remainder of this statement, I will summarize the key elements of the NASA programs relevant to this subject.

Improvements in the precision and detail of weather information in the terminal area represents a serious need, as has been illustrated by several recent accidents. The hazards posed by low-altitude wind shear have become the

focus for substantially increased attention throughout the aviation community. NASA is working with the FAA and other agencies to address this concern by pursuing the technology to forecast and detect wind shear from both the airplane and the ground. The NASA research is focused on airborne detection and the development of better atmospheric models for use both in training simulators and in advanced controls and displays.

Flight operations in the terminal area have been the subject of extensive NASA research. The emerging capabilities now available in avionics, guidance systems, and on-board computation and automation offer significant promise for large increases in system and aircraft efficiency, while reducing conflicts between aircraft in the crowded terminal area. Already demonstrated is the abilit[illegible] arrive at a predetermined point such as the runway t[illegible]shold at a precise time while maintaining a fuel-optimum flight path. Improved precision in landing flare and touchdown has been demonstrated in an automatic flare guidance program which has reduced touchdown dispersion from 1000 to 100 feet. This increase in touchdown accuracy is both a significant safety improvement and a necessary first step in reducing runway occupancy time. Other steps, such as rollout guidance and automatic high-speed turnoffs are technology areas that are currently being pursued. Other research efforts aimed at the technology for conducting parallel instrument approaches with substantially reduced lateral separation are also underway. NASA is working with the FAA and the industry to insure that these capabilities can be integrated into the air traffic control system.

Planning for the future poses a difficult challenge for the airport designer. Runways, taxiways, and gates must be designed to accommodate a wide range of aircraft including very large aircraft, small aircraft and those with unique capabilities. The airport should be designed with sufficient flexibility to adapt to new aircraft and airport technology as it becomes available. Effectively accommodating aircraft with diverse capabilities, i.e., rotorcraft, general aviation, commuters, STOL aircraft, conventional subsonic transports, and supersonic or hypersonic transport aircraft such as the Orient Express requires careful consideration of their special capabilities and requirements. Operation of an Orient Express, for example, will require the airport to provide for the production, storage and delivery of cryogenic hydrogen fuel.

I appreciate the opportunity to share with you NASA's vision of the exciting new prospects for aircraft of the future. We look forward to working with the airport planners, airlines, aircraft manufacturers, and regulators to maximize the opportunities in the design of the new Denver airport.

Figure 1: Subsonic Transport

Figure 2: Tilt Rotor Transport

Figure 3: X-Wing Rotorcraft

Figure 4: Supersonic Transport

Figure 3: Supersonic Transport

Mr. GEORGE BROWN. Our next witness this morning will be Mr. Neal Blake, Deputy Associate Administration for Engineering at the FAA. We appreciate your helping us out this morning. You may proceed. And your statement is—you might want to shorten it up a little bit, Mr. Blake.

STATEMENT OF NEAL A. BLAKE, DEPUTY ASSOCIATE ADMINISTRATOR FOR ENGINEERING, FEDERAL AVIATION ADMINISTRATION

Mr. BLAKE. Thank you, Mr. Chairman. I would like to hit just a few of the high points, if I might.

We certainly appreciate this opportunity to review some of the areas covered by our research, engineering, and development program in airport technology and capacity. As we look ahead toward the 21st century, we expect the types of aircraft to be much as they are today, but with some very significant changes. The next generation fuel efficient aircraft, that you were shown a few minutes ago, is expected to enter the fleet during the mid-1990 time period. The other major change that we see is that the number of stage 2 aircraft—that is, aircraft meeting stage 2 noise standards—will drop from about 80 percent in 1985 to less than 11 percent by the end of this century. And I think that is good news for all of us.

And for the longer term, Dr. Colladay has pointed out to you some of the more advanced vehicles that must be handled by the airports of the future.

With regard to growth, domestic air carrier, revenue passenger miles are forecast to increase at a rate of about 4.2 percent annually, and domestic employments are forecast to increase by about 4.4 percent through the end of this century. Aircraft operations are forecast to increase at an annual rate of about 2.1 percent over this same time period. And forecast growth for Denver from 1984 to about the year 2000 is about 41 percent, which is a very substantial amount.

We are, of course, pleased to note that Denver is planning to build a totally new airport to provide the facilities needed to accommodate future growth in this area, and it also provides the opportunity to incorporate some of the newer technology.

Today, I would like to touch briefly on some of our programs in the aircraft capacity, technology, and weather areas, which have potential for providing future improvements in capacity and safety.

Perhaps the most extensive NAS plan program is the advanced automation system. In the near term, it will improve FAA's air traffic control computer system, its capacity, reliability, availability, expandability, and will improve the controllers' interface with the systems for better displays and data entry systems. The AAS automation system will initially include not only new software in the controllers' suite, but also the first steps of our future automated en route air traffic control system. It is significant to note that it will enable users to fly their preferred trajectories far more of the time.

A related improvement is our effort to reduce vertical separation above flight level 290 to 1,000 feet, and to continue to examine the potential for reducing horizontal separation.

As noted earlier, in a joint program with NASA, we are working toward a system that will permit aircraft to utilize their growing 4-D navigation capabilities to meet metering schedules in order to make best use of the capabilities becoming available in these aircraft.

Research, engineering, and development is planned to follow onto this beginning of air traffic control automation to improve the degree to which user preferred trajectories can be achieved, based on a better knowledge of airport capacity, estimates, and prediction. The second phase of the automated en route air traffic control program will analyze flight plans and associated surveillance data to identify controllers' alternative solutions for resolving air space and aircraft conflicts in an efficient manner.

Later, in the third stage of automation, AERA III, to analyze flight plans and associated surveillance data, and to send clearances which are generated automatically and transmitted automatically by data link. The traffic management system, an extension of the central flow facility and system command center is a program of major importance as part of the NAS plan of modernization. Its purpose is to smooth the flow of traffic to achieve the highest system of efficiency, taking into account the real limitations on system and airport capacity; and the need to manage flows to permit optimal aircraft operation for everyone.

The RE&D Program here is required in the near term to achieve a traffic management system that matches traffic demand to available terminal and en route capacity.

Reduction of longitudinal arrival spacing between certain aircraft pairs, applicable at airports where runway occupancy time has been found to be less than 50 seconds, is a near term method of increasing airport capacity. We believe we can reduce separations between like aircraft in the medium (weight) category from 3 miles to 2½ miles. And we have been taking data in a number of airports to support this reduction in the relatively near term. We see this as a major contribution to increased capacity.

Independent IFR operations to closely spaced parallel runways, we are working here to define the things that have to be done to reduce the required separation from the current 4,300 feet to 3,000 feet, or possibly even less. And this has application at 10 existing airports, and we believe several additional airports are likely to build new runways if they could be used independently.

The FAA analysis is tied to some real time simulations which we conducted at our technical center, specifically with reference to the Memphis Airport, where we have been taking data over the last year, I think the simulation has confirmed that it is feasible; however, we will require a surveillance sensor which is somewhat better than the current airport surveillance radar.

A preliminary study of IFR converging approach criteria has been completed. Sixteen of the top 40 airports are candidates for IFR approach minimums reduction for converging runways. Work has proceeded to the development of a first criterion on which improved IFR converging operations can be authorized today. The FAA hopes to issue the revised procedure for implementation this year.

A concept for triple-IFR approaches is ready for consideration by our industry task force. The work on triples is in series with the work on parallels and converging approaches, since triple operations often involve two parallels and one converging runway.

The technical analysis here must concentrate on aircraft navigation performance and the missed approach and blunder possibilities which could occur during triple operations.

Of the top 30 airports, 11 could benefit from enhanced use of short runways for aircraft with slower approach speeds and shorter runway requirements than those required for large aircraft. And, of course, we recommend that for handling commuter and general aviation aircraft.

Aircraft capacity, of course, is seriously impaired or reduced by the requirement for weight-vortex separations which run 3, 4, 5, or 6 miles, depending on the aircraft types in a particular sequence, as well as the wake-vortex departure spacing.

We are continuing to work to find operational means to avoid the capacity penalties resulting from the wake-vortex hazard.

We have underway research and development on a departure flow metering system to assure the best bridge between the needs of the airport to flush out airplanes and the capability of the transition and en route system to accept them. For the longer term, demands on airport capacity will continue to increase and an all-weather airport, surface, surveillance, guidance and control system will be required. We are currently procuring airport surface detection radar, called ASDE. This program will be extended to evolve a full-scale, surveillance and guidance and control system for the airport surface.

The mode S data link will play an important role in the improvement of near and on airport communications, and may serve a valuable role in certain surface surveillance applications. Data link is the best way to convey the massive routine information which the pilot and controller need about airport operations.

MLS represents a most promising system for facilitating further separation reductions. We believe it will have a role in achieving lower minimums for IFR converging approaches, for triple runway operations, in the separate short runway applications, and to segregate aircraft in multiple airport environments to reduce interaction.

We will continue to examine airport designs to identify improvements that will enhance airport capacity and be compatible with new aircraft at both ends of the spectrum. And on the one end, the rotor craft and the light aircraft; and on the other end, the transonic and hypersonic aircraft we are beginning to talk about.

For a number of years, nearly 65 percent of all airport improvement program grant money has been expended on runways and taxiways. The FAA, assisted by the Federal Highway Administration and others, have worked in the area of pavement research for many years. But additional work is planned as product improvement, and to overcome the not infrequent runway outages for repair and rebuilding.

Our R&D Program will continue to support research in pavement durability and repair, as well as airport safety systems, as a complement to our Airport Capacity Program.

At this time, I would like to touch very briefly on the highlights of our program to improve the observation, processing, and dissemination of weather information.

The hazardous in-flight weather advisory system is operational in three of our air traffic control center areas, and will be extended to provide nationwide coverage in 1987. This system provides forecast information on severe weather in the form of SIGMETS and current information on severe weather hazards in the form of center weather advisories. This information is generally broadcast over VOR frequencies.

Use of displays of existing National Weather Service radar by controllers in the air traffic control tower was examined at several of our towers. This examination indicated that insufficient data was available to identify hazardous weather phenomena existing within the precipitation contours which are presented on our ACT displays. Discussions are in process with the National Weather Service to determine whether hazardous weather contours could be developed in the National Weather Service facility; sent to the air traffic control facility for display to the controllers.

Significant progress has been made in the wind-shear program area. A contract was awarded during 1985 to a team of companies to develop a comprehensive pilot training program in wind shear. This program will develop a course of instruction in the nature of a wind shear hazard, recognition and avoidance of wind shear, and piloting techniques that will provide the best performance should an aircraft actually encounter a shear.

A joint program has been initiated with NASA-Langley on the development of airborne systems for detection of wind shear and for provision of flight guidance to pilots in avoiding or obtaining the best aircraft performance if a shear is encountered.

The next generation weather radar program is now in the prototype test phase, and we expect an award for the limited production system in January or February of 1987. During fiscal year 1986, the two NEXRAD contractors conducted design studies for a terminal variant of the NEXRAD system. Two of the limited production NEXRAD systems will be delivered with the terminal modifications in place and the remaining 13 terminal variants will be delivered as a part of the production contract. We hope to initiate in fiscal year 1988 a new program to buy additional versions of the terminal Doppler weather radar.

During 1985, we tested our prototype of the terminal Doppler radar at Memphis, TN, and during the test period, which covered the summers of 1984 and 1985, nearly 100 microbursts were detected in the Memphis area. And two of these actually occurred in the approach and departure paths of the Memphis Airport.

Implementation of the low-level wind-shear alerting system at 110 sites is being completed this year. R&D leading to the definition of an enhanced system will also be completed this year. The enhanced system will have additional sensors for improved processing, data recording and archiving, and improved display formats. Wind shears will be reported in along runway and across runway components. We believe this format will be easier for pilots to use.

In the automated weather observing system we have solved the sensor problems that we have in the past, and are currently in the

production design phase on that contract. In addition, we are planning to start a second procurement for additional systems, and these will be installed in nontower airports, which currently have no weather service.

Development of the central weather processor is continuing. This sytem accepts information from NEXRAD radars and metereological products from the National Weather Service, and provides processed information to metereologists. The metereologist uses the information to prepare aviation short-term forecasts and severe weather advisories. In addition, he generates graphical products identifying weather hazards. The processed products generated by the metereologist and by the automatic algorithms will be provided to the controller as an overlay on the traffic display, and to the pilot by data link.

And, finally, because of the interest in aviation security, we are continuing research in advanced explosive detection systems for baggage and cargo inspection, improved concourse security through an integrated system, explosive vapor detection systems for detection of explosives and flammable liquids carried by passengers, and the best methods of handling bombs which are discovered after the aircraft is in flight.

And with that, this completes the formal part. I would be happy to answer any questions you may have.

Mr. GEORGE BROWN. Thank you very much, Mr. Blake.

Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. Blake, comments were made in earlier testimony about disagreements between the FAA and the efforts of the city/county of Denver and Adams County. Do you believe that those concerns can be mitigated and adequate agreements can be reached that would meet the approval of FAA?

Mr. BLAKE. Well, I am not at all familiar with the local situation. But I do know that we are working with the local people here, particularly in the area of establishing acceptable air traffic control procedures, which would tend to minimize noise. And I think I can assure you that we will continue to work with you in the process of developing the appropriate procedures for the new airport.

Mr. PACKARD. Generally, does the FAA have an attitude regarding the closing down of one airport when they open a new one?

Mr. BLAKE. I don't know. I am not that familiar with it, sir.

Mr. PACKARD. Has FAA been studying ways to move people on the ground? Now, certainly there is a great deal of work being done in more effectively and more efficiently moving people in the air from point to point. But getting to and from an airport, handling baggage, and traffic problems around an airport, and parking, and all those related problems before getting on an airplane, those are creating significant problems at many of our airports, and Stapleton is no exception to that.

Has FAA done any studies, or do you feel that is within your purview to study those areas?

Mr. BLAKE. Well, our purview, if you will, is pretty much restricted to the air-side of the airport, and the nonrevenue producing parts of the terminal building. And we have documents that provide guidelines both for airport design, pavement design, and ter-

minal building design, excluding the revenue or concession parts of the airport. Our authority does not go out into the highway access.

Mr. PACKARD. I will reserve my questions on that to other witnesses, then.

Dr. Colladay has presented some very interesting information on new research, new aircraft of a variety of natures that will accommodate a variety of air transport, types of air transport. Has FAA done studies to determine how new airports would be designed to accommodate the new technology that obviously is coming down; and do you have any feel for what kind of new technology will be required in addressing a new airport to accommodate such aircraft?

Mr. BLAKE. We have received a number of very comprehensive briefings from NASA, where they have told us, to the extent that they exist, what the expected characteristics of the new vehicles will be like. And, yes, as that information is made available we do use it in formulating our R&D plans and also the FAA policies that relate to airport design.

Mr. PACKARD. What kind of additional problems and challenges do you see with these new aircraft for airport design?

Mr. BLAKE. Well, actually, the newer aircraft will have better climb characteristics. They tend to get up and away faster, which is a tremendous boon to the air traffic control system; if they can get the aircraft to altitude quicker, that is a substantial benefit to us. It reduces the terminal area congestion quite a bit. They are very much quieter. And as I noted in the testimony, we expect the numbers of these stage 3 quieter aircraft to increase dramatically during the next decade.

So, in general, we are as anxious as others are to see the new generation aircraft enter the system.

Mr. PACKARD. So your general feeling is that the new generations of aircraft will actually solve some of the problems that we have been struggling with, rather than create new problems?

Mr. BLAKE. Yes; I think so. And, also, mention was made by both of us that on board these aircraft you are finding much more capable flight guidance, flight management systems, navigation systems, which will allow them to generate and transmit to the ground air traffic control system a desired fuel efficient profile. And we will be able to put on the ground a matching automation package which will let the operators of these aircraft have the more efficient profiles most of the time. We think that direct interconnection by data link between the airborne and ground-based computers will result in much greater efficiency of operation.

Mr. PACKARD. You mentioned also in your testimony that significant progress has been made and is being made in airport security. The—in that progress, do you sense that the implementation of that new—those new procedures will delay or slow down the ground movement to any degree?

Mr. BLAKE. I think that——

Mr. PACKARD. Either aircraft or personnel.

Mr. BLAKE. I think I can say without saying too much on this subject that the devices that are coming along will probably not have much impact on the rate at which baggage and cargo are handled. We are developing much improved devices for that.

Mr. PACKARD. One last question, Mr. Chairman.

From a general point of view, do you feel that safety is improving or do you feel that we are finding more and more cause for concern and alarm with safety issues?

Mr. BLAKE. I think safety is improving. I think out of our R&D Program we are developing devices that get right at some of the root causes of accidents. The one that was mentioned earlier was the terminal Doppler weather radar and the positive impact that can have on safety. I think we are beginning to get solutions to most of them. We are, however, in a joint program with NASA, addressing perhaps the most difficult one, the question of pilot performance in a fully—highly automated, fully automated environment, and the design of systems that are human error tolerant. I think that is an area that——

Mr. PACKARD. Human error——

Mr. BLAKE. Human error tolerant.

Mr. PACKARD. Human error tolerant.

Mr. BLAKE. We have, for example, completed a project recently which involved the major aircraft manufacturers, to give the pilot information when there have been catastrophic failures on the aircraft, as to the nature of the failure and what the proper procedures are to recover that aircraft. And we think that some aircraft that were lost in the past, by putting these systems on the new aircraft, we can prevent those losses in the future.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Continuing with this question of airport security for a moment, the priority of that issue, of course, waxes and wanes, depending upon whether we have had a recent example of terrorist attack or something of that sort.

You have indicated that you feel improved security measures can be developed, are being developed which will not markedly delay the time of passengers—processing of passengers and cargo. Looking at the matter from the standpoint of airport design, is it possible that in designing a new airport, like Denver, that there could be design changes made that would increase the security of the airport substantially; or are such design changes not really necessary to the enhancement of security?

Mr. BLAKE. Well, I think we are making available the technology which can be incorporated into airports that will make the detection of explosive devices much easier and much more positive.

A sideline is that some of these also work to pick up drugs, like cocaine, which is an interesting feature as well. But we are working beyond that on procedures that might be helpful in thwarting terrorist activity; and also on concourse security systems, as an integrated system of many sensors that would help to identify all substances.

Mr. GEORGE BROWN. Well, it seems to me that we are talking about sensors and the location of sensors and so forth; that there is not much relationship between this and the actual design of the airport building structures themselves. I note that it seems to be possible to direct traffic and channel traffic through control points and so forth, in almost any kind of an airport. But I am not urging that we design them especially for that purpose. I just wondered if that factor had been given any thought.

Let me ask you to comment on another thing. You made several references to the 4–D capability, which I presume refers in general to locating in time and three dimensions aircraft at any particular time for better control purposes.

Does any of this encompass the possibility of utilizing the satellite capability which will be in place in the not too distant future, the systems which can be used to locate not only aircraft, but almost anything with the proper black box on the surface of the Earth within a relatively short distance; 50 feet, I understand, or something like that? Any discussion or consideration of integrating this satellite system with the air system?

Mr. BLAKE. Yes. We are assuming—are working actively on two areas. One is the integration of the global positioning system as an approved navigation system throughout the world, really, but particularly throughout our national aerospace system.

The second thing we are looking at is the possibility of early implementation of an automatic dependence surveillance system, particularly for oceanic areas, initially; and, also, for low-altitude helicopter operations where the aircraft could report its navigation position and particularly its GPS satellite position through an existing commercial satellite link to an air traffic control facility. When sufficient aircraft would be equipped with that particular equipment, it opens up the possibility of reduced lane widths, that is, more roads, if you will, across the ocean; and closer separation between aircraft for the longer-term direct route flights with about a 5-percent fuel saving across the North Atlantic. And this is being discussed not only nationally, but with the international organization as well. And they are working toward setting standards for such a service at the present time.

Mr. GEORGE BROWN. Such a system, of course, would have precluded tragedies such as the KAL–007 accident or other similar matters?

Mr. BLAKE. Yes. Because it would allow the air traffic control systems around the world to have a pseudo-radar environment, if you will, and to know where the aircraft is.

Mr. GEORGE BROWN. Mr. Blake, I do not want to embarrass you. But with all this important research and development that we have in prospect and the need for, do you feel that the FAA is receiving the R&D budget necessary to really conduct a vigorous program in all these areas?

Mr. BLAKE. Yes. I think the Congress has given us very good support over the years. We are hoping that over the next several years we can begin to start some longer-range activities that we have deferred in the process of getting a NAS plan modernization in place. And we will, I hope, be coming to you, perhaps as early as the 1988 budget, with some suggestions for perhaps the longer-term period of time that these new aircraft you've heard about will be coming into being; and the need to get out that fresh sheet of paper that I already talked about, and start designing the system around the capabilities of these new vehicles.

Mr. GEORGE BROWN. I think the Congress is going to be supportive of whatever requests of that sort you make. I think your problem may be convincing the OMB of the necessary priority of some of this long-range research. If you have any ideas about how the

Congress can help you with that, we would be glad to have you share them with us.

Do you have any further questions?

Mr. PACKARD. I think there is one fundamental question that ought to be asked of the FAA before we release the witness.

Denver and Stapleton is being redesigned to accommodate significantly more air traffic. That is based upon the fact that Denver is a significant hub. With new aircraft, a new generation coming on with much longer travel, cross-country travel, or perhaps some new regulations or new attitudes on the hub-and-spoke system, it could feasibly alter the traffic out of a hub like Denver.

What is your response to the possibility that they may be overbuilding a facility that later could change simply because of the changes in the nature of air travel?

Mr. BLAKE. Of course, many things can happen in the future. But I think the airlines at the present time feel that that type of operation is perhaps one of the better ones, as far as they are concerned. And they are the ones that really make the decision on what type of operation is most profitable for them. And I do not see anything that would change that picture dramatically during the next decade or so. Beyond that, my crystal ball is cloudy.

Mr. PACKARD. $1.7 billion is quite an investment, and I think they would want to see a crystal ball relatively clean before they invested.

Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Thank you very much, Mr. Blake, for your testimony.

[The prepared statement of Mr. Blake follows:]

STATEMENT OF NEAL A. BLAKE, DEPUTY ASSOCIATE ADMINISTRATOR FOR ENGINEERING, FEDERAL AVIATION ADMINISTRATION, BEFORE THE HOUSE SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS, CONCERNING AIRPORT TECHNOLOGY, JULY 28, 1986.

Mr. Chairman and Members of the Subcommittee:

I appreciate this opportunity to review the areas covered by our Research, Engineering and Development (R,E&D) Program in airport technology and capacity. I believe that these programs will provide the improvements needed to increase airport capacity and the design guidelines that will permit future airports to operate productively. Today I would like to address some of the topics that were included in your letter of invitation.

In looking ahead to the 21st century, we expect the types of aircraft to be much as they are today but with several significant changes. A next generation fuel efficient aircraft, most probably powered by advanced turboprop engines, is expected to enter the fleet starting in the mid-1990 time period. The continued introduction of present generation quieter aircraft is expected to reduce the number of aircraft meeting the older noise standards from 79.6 percent (1985) to 11 or less by 2005.

For the longer term, NASA is exploring the feasibility of developing an economical long-range supersonic transport capable of flight legs up to 5,000 miles. Work is also underway on a transatmospheric vehicle capable

of flying from Denver to Sydney in 2 hours. Both of these new aircraft types will be designed to operate into existing major airports. Since Dr. Raymond Colladay of NASA is addressing the future aircraft area, I will not go into that subject any further.

Domestic air carrier revenue passenger miles are forecast to increase at an average annual growth rate of 4.2 percent during the 1985-2005 time period. Domestic enplanements are forecast to increase by 4.4 percent annually during the same period. Air carrier aircraft operations are forecast to increase at an annual rate of 2.1 percent over the forecast period. The high growth in revenue passenger miles and enplanements relative to operations reflects the baseline air carrier assumptions of higher load factors, larger seating capacity for air carrier aircraft, and longer passenger trip lengths.

The FAA forecast for aircraft operations at large hub airports shows a projected growth for Denver airport for the period 1984 to the year 2000 of about 31 percent.

The FAA is pleased to note that Denver is planning to build a totally new airport to provide the facilities needed to accommodate future growth in this area. It also provides the opportunity to incorporate the latest design features and technology into the new design.

Today I would like to review briefly some of our programs in the airport capacity, airport technology, and weather areas which have the potential

for providing future improvements in capacity and safety.

The FAA program addresses factors which limit system and airport capacity. The first is the requirements for separation, in the air and on the airport, largely imposed by the overriding requirement for safety. The separation standards have a major impact on capacity in the airspace, the terminal area, and on the airport itself. Safe reductions of separation standards based on better navigation, better surveillance, or better communications can yield dividends in the immediate airport vicinity. It is a major source of airport capacity improvement at existing airports.

The second area concerns variability in aircraft performance, again in the airspace and on the airport. Runway occupancy time variation, variation over the threshold, and variability of aircraft performance in the air constrain achievable capacity; reductions in variability increase it.

Finally, system capacity is limited by the quality and availability of information for management of resources, both in the aircraft and in the air traffic control system. Timely information on aircraft location, current and predicted capacity limits, winds aloft, severe weather, ceiling and visibility limits, sector loading, and a number of other factors establish the level of efficiency of system management. Much of the work we are doing in the National Airspace System (NAS) Plan concentrates on the improvement in the quality and timeliness of

information and information flow, because it, perhaps more than any other factor, determines the efficient utilization of available capacity.

The goals for the capacity improvement program, therefore, are to safely reduce separation standards, reduce variability of performance, and to better manage resources to increase system capacity through improved procedures, better surveillance, navigation, and control systems, and new and improved information processing systems.

Perhaps the most extensive NAS Plan program is the Advanced Automation System. In the near term, it will improve FAA's air traffic control computer system capacity, reliability, availability, and expandability. It will improve the controller's interface with the system through improved displays and data entry terminals.

The Advanced Automation System will initially include not only new software and a new controller's sector suite but will also include the initial capabilities of the Automated En Route Air traffic control program (AERA I). It will enable users to fly their preferred trajectories far more of the time. A related capacity improvement is the effort to utilize reduced vertical separation above flight level 290 and continued examination of the potential for reduced horizontal separation.

In a joint program with NASA, we are working toward a system that will permit aircraft to utilize their growing 4-D capabilities to meet metering schedules in order to make best use of the capabilities becoming

available in a number of aircraft.

One of the tasks we are planning to undertake in this area is to assure that we can efficiently accommodate aircraft with 4-D area navigation capabililty, and to establish the optimal dynamic control of approach and landing times by automatic communications between 4-D equipped aircraft and the ground system, to establish the best dynamic balance between the operator's wishes and the efficient use of the airport.

R,E&D is planned to follow-on to this beginning of air traffic control automation to improve the degree to which user preferred trajectories can be achieved, based on better knowledge of airport capacity estimates and predictions. To the degree that the information quality permits us to do it, the second phase of the automated en route air traffic control program (AERA II) will analyze flight plans and associated surveillance data to identify, for controllers, alternative solutions for resolving airspace and aircraft conflicts, and later, in AERA III, to analyze flight plans and associated surveillance data to data link computer-generated clearances automatically -- first at high altitudes and then moving down to the lower altitudes and into the terminal environment. This automation effort is expected to result in one of the largest increases in system productivity and capacity that the NAS Plan promises. It will require full exploitation of digital data link.

The Traffic Management System, an extension of the Central Flow Control Facility and the System Command Center, is a program of major importance

as part of the NAS Plan System modernization. The Traffic Management System is viewed by some as a mechanism for constraint, rather than capacity enhancement, but constraint is not its purpose. Its purpose is to smooth the flow of traffic to achieve the highest system efficiency, taking into account the real limitations on system and airport capacity and the need to manage flows to permit optimal aircraft operation for everyone. The key to efficient flow management is information on winds aloft, weather--current and predicted, on current and projected sector loading and, perhaps most importantly, clear knowledge of current and projected near-term airport capacity. The degree to which time-based air traffic control can be achieved depends entirely on the quality of information available to the Traffic Management System. The R,E&D required for the near term is to achieve a Traffic Management System which matches traffic demand to available terminal and en route capacities.

One of the most difficult parts of the Capacity Improvement Program relates to the major airports and the terminal areas serving them. One of the tasks is to assure a solid bridge between en route operations and terminal area/airport operations in order to optimize the performance of the total system. We want to accommodate more aircraft per hour, eliminate wasted capacity by reducing variability, and to develop improved information processing systems to manage system resources better. The FAA has been working in this area for a long time.

However, before describing our projects, it is important to emphasize

that the biggest capacity gains are achieved from more runways and more airports. Our attempt to equalize VFR and IFR capacity, and some of the projects I will describe, each offer relatively small percentage gains. However, they are worthwhile if you keep in mind that even a small increase in capacity can result in as much as a 5 to 1 reduction in delay costs at an airport nearing congestion.

The first is the reduction of longitudinal arrival spacing between certain aircraft pairs, applicable at airports where runway occupancy times have been found to be less than 50 seconds. We believe 2.5 miles can be achieved for certain IFR operations. A formal data collection for demonstration of this capability has been conducted for both dry and wet runway conditions. Our initial 500 data pairs at three airports (Dallas/Fort Worth, Atlanta, and Newark) have resulted in no-go arounds and no reports of wake turbulence, and only one pilot declined to participate in the demonstration. We hope to implement the reduced longitudinal separation standards for certain aircraft in the medium weight class in the near future.

Independent IFR operations to closely spaced parallel runways - reducing the required separation from the current 4,300 feet to 3,000 feet or potentially even less - have immediate application at 10 airports, and several additional airports are likely to build new runways if they can be used as independents. The FAA analysis, strongly supported by almost the entire industry, led to a real-time simulation conducted by the FAA Technical Center using Memphis where the separation between two parallel

IFR runways is 3,400 feet. The simulation confirmed that this separation is feasible for independent IFR operations if a better sensor is used than the present ASR. Using a modified Navy/Marine Corps radar, we conducted a 6-month demonstration to validate the width of the normal operating zone (NOZ) which determined the safe minimum. Based on this data from Memphis, we hope to extrapolate to determine the adequacy of the procedure and the requirement for surveillance quality to achieve 3,000 feet-separated independent parallel IFR operations.

Also based on an earlier study, a preliminary study of IFR converging approach criteria has been completed. Sixteen of the top 40 airports are candidates for IFR approach minimums reduction for converging runways. The work has proceeded to the development of a first criterion on which improved IFR converging operations can be authorized. The FAA hopes to issue the revised procedure for implementation in the near future. Another aspect of this work is the development of a single criterion on which converging approach operations can be judged. The approach to that single criterion is about to go into coordination with the Industry Task Force. There is follow-on work which would establish the requirements to achieve converging approach minimums similar to those for Category I precision approaches, but that work remains to be done.

A strawman concept for triple IFR approaches is ready for consideration by the Industry Task Force. The work on triples is in series with the work on parallels and converging approaches since triple operations often involve two parallels and one converging runway. The technical analysis

here must concentrate on aircraft navigation performance and the missed approach and blunder possibilities during triple operations. While the concept applies to only a few airports at the moment, the lack of procedures for such operations discourages airport operators from planning for them in the future.

Nearly 70 of the top 101 airports have short, often converging runways. Eleven of the top 30 could benefit from enhanced use of the short runways for aircraft with slower approach speeds and shorter runway requirements than those required for large aircraft. Site-specific analysis is required to establish the best use of separate arrival and departure streams and optimal separation to make beneficial use of short runways. The Microwave Landing System (MLS) will have a major beneficial impact. Full short runway utilization will be dependent on implementation of other concepts being considered in the converging and parallel triple Instrument Flight Rule (IFR) approach programs. Work on each of these is well along.

Airport capacity is, of course, impacted seriously by the requirement for wake vortex separations -- 3, 4, 5 and 6 miles depending on the aircraft pair, as well as wake vortex departure spacing. We are continuing work to find operational means to avoid the capacity penalties resulting from avoidance of the wake vortex hazard.

The Traffic Management System has an important impact on best utilization of airport capacity. We have underway research and development on a

departure flow metering system to assure the best bridge between the needs of the airport to flush out airplanes and the capability of the transition and en route system to accept them.

For the longer term, demands on airport capacity will continue to increase, and an all weather airport surface surveillance, guidance, and control system will be required. We are currently procuring airport surface detection radar (ASDE). This program will be extended to evolve a full-scale surveillance, guidance, and control system for the airport surface.

The Mode S data link will play an important role in improvement of near and on airport communications and may serve a valuable role in certain surface surveillance systems. Data link is the best way to convey the massive routine information which the pilot and the controller need about airport operations.

MLS represents a most promising system for facilitating further separation reductions. We believe it will have a role in achieving lower minimums for IFR converging approaches, for triple operations, in the separate short runway applications, and to segregate aircraft in multiple airport environments to reduce interaction.

Today there is limited automation in our terminal operations. We have not demonstrated that machines can juggle the many variables as well as human controllers. Our program will concentrate on ways that initially

can help the controller in establishing the best approach paths. We have done some work in this area with two universities.

But we need to go even further. Programs are being initiated to provide increased automation in airport operations. We plan to undertake research and development in several areas:

- Analysis of the potential benefit of highly automated terminal area guidance and control systems.

- Analysis of optimal aircraft control methods to achieve precise threshold crossing times.

- Use of computer-guided approaches, either a computer on the ground, a computer on the aircraft, or a combination of the two.

- Optimize and regularize runway occupancy time, one of the major variables affecting airport capacity.

- Automation of surface traffic movement, including aircraft management to achieve runway occupancy time reduction and standardization.

- Definition of methods of airport/aircraft control/command alternatives, required response times, optimum exiting strategies, establishment of data quality, and update requirements for

automatic airport operations.

- Evaluation of alternative means of providing the necessary surveillance data quality and trade-off studies on different surface sensing systems.

We will continue to examine airport designs to identify improvements that will enhance airport capacity and be compatible with new aircraft at both ends of the spectrum, the rotorcraft and light aircraft at one end and the transonic and hypersonic aircraft we are beginning to talk about.

For a number of years, nearly 65 percent of all Airport Improvement Program (AIP) grant money has been expended on runways and taxiways. The FAA and the Federal Highway Administration have worked in the area of pavement research for many years, but additional work is planned as product improvement and to overcome the not infrequent runway outages for runway repair and rebuilding. The Industry Task Force has strongly recommended work in this area. In order to help identify the most fruitful areas of research, the FAA Airports organization sponsored a project by the Army Corps of Engineers Waterway Experiment Station (WES) to survey and establish a needs statement for this work. A report has been developed and submitted to the Industry Task Force for their consideration. This report is being used in formulating our R&D Program which will continue to support the research on pavement durability and repair and airport safety systems, to complement airport capacity improvement.

It has been noted several times that the achievement of major gains in airport capacity comes from construction of new airports and new runways. Several of the R&D projects covered above encourage such construction. For example, the expanded use of multiple IFR arrival streams encourages new runway construction at existing airports to take advantage of the new concepts. MLS can allow separate access to major airports by general aviation and other MLS-equipped aircraft and this, in turn, will encourage development of separate short runways to facilitate such separate access. The capability to achieve efficient multiple IFR arrival streams will also help in supporting airport designs which take advantage of these capabilities.

It goes without saying that a number of the weather programs will have a direct impact on airport capacity, not only the wake vortex detection and avoidance effort but also the efforts to provide better severe weather and wind shear information and better data on winds aloft and wind on the approach path.

At this time, I would like to summarize some of the highlights of our program to improve the observation, processing, and dissemination of weather information.

o The hazardous in-flight weather advisory system is operational in three air traffic control center areas and will be extended to provide nationwide coverage in 1987. This system provides forecast information

on severe weather, in the form of SIGMET's, and current information on severe weather hazards in the form of Center Weather Advisories. This information is generally broadcast over VOR frequencies.

o Use of displays of existing National Weather Service radar by controllers in the air traffic control tower was examined at several towers. This examination indicated that insufficient data was available to identify hazardous weather phenomena existing within the precipitation contours presented on the weather displays. Discussions are in progress with the National Weather Service to determine whether hazardous weather contours could be developed at a National Weather Service facility, transmitted to the weather display in control tower, and presented in near real time to the controllers.

o Significant progress has been made in the wind shear program area. A contract was awarded during 1985 to a team of companies to develop a comprehensive pilot training program in wind shear. This program will develop a course of instruction in the nature of the wind shear hazard, recognition and avoidance of wind shear, and piloting techniques that will provide the best performance from an aircraft should a shear be encountered.

o A joint program has been initiated with NASA Langley on the development of airborne systems for detection of wind shear and for provision of flight guidance to pilots in avoiding or obtaining the best aircraft performance if a shear is encountered. The program addresses

several areas. One is the improvement of existing detection systems to determine the degree to which these systems can detect both wet and dry microbursts. One activity is designed to determine the extent to which airborne Doppler weather radar performance can be improved for the detection of microbursts. This is a very difficult task since the radar antenna is small, the transmitter of low power, and the processing to remove ground clutter extremely difficult. A second effort in the sensor area will determine the extent to which laser lidar devices and other technologies can be developed to detect microbursts generally and in particular dry microbursts. Another part of the program addresses improvements that can be made in the flight guidance provided to the pilot during recovery from a wind shear encounter. A related activity is continuing the characterization of the wind shear hazard. This activity will determine the flight guidance improvements needed to account for the effects of the ring vortex properly which forms at the outside edge of the microburst. A future task will address the integration of forward-looking sensors with the improvement in flight guidance to provide a system that will allow the pilots to detect and avoid wind shear conditions.

o The Next Generation Weather Radar (NEXRAD) Program is now in the prototype test phase. The award for limited production systems is expected in January 1987.

o During FY 1986, the two NEXRAD contractors conducted design studies for a terminal variant of the NEXRAD systems. Two of the limited

production NEXRAD systems will be delivered with the terminal modifications in place. The remaining 13 terminal variants will be delivered as part of the production contract.

o During 1985, the FAA tested a prototype of the Terminal Doppler Weather Radar at Memphis, Tennessee. This program resulted in the definition of technical parameters including scanning strategies and types of displays and initial testing of the automatic detection and warning algorithms. During the test period which covered the summers of 1984 and 1985, nearly 100 microbursts were detected in the Memphis area. Of these, two occurred in the approach and departure points of the Memphis airport. Approximately 25 percent of the microbursts were dry. In the fall of 1985, the system was moved to Huntsville, Alabama, and will be used during 1986 for further development and testing of the automatic detection and warning algorithms which will ultimately provide microbursts warning to tower controllers. The FAA radar will be operated in conjunction with Project Microburst Severe Thunderstorm (MIST) which is a joint program of the National Science Foundation and the University of Chicago to study microbursts and severe thunderstorm activity in the humid southeast part of the United States.

o Implementation of the Low Level Wind Shear Alerting System at 110 sites is being completed. R&D leading to definition of an enhanced system will be completed this year. The enhanced system will have additional sensors for improved processing, data recording and archiving, and improved display formats. Wind shears will be reported in "along

runway" and "across runway" components. We believe this format will be easier for pilots to use.

o In the Automated Weather Observing System (AWOS), we have solved the sensor problems that we had in the past and are currently in the production design phase of the AWOS contract. In addition, we are planning to start a second procurement for additional systems. These systems will be installed at nontowered airports to provide basic meteorological information including wind speed and direction, temperature, dew point, altimeter setting, visibility, cloud height, and precipitation.

o Development of the Central Weather Processor is continuing. This system accepts information from the NEXRAD radars and meteorological products from the National Weather Service and provides processed information to meteorologists. The meteorologist uses the information to prepare aviation short-term forecasts and severe weather advisories. In addition, he generates graphical products identifying weather hazards. The processed products generated both by the meteorologist and by the automatic algorithms will be provided to the controller as an overlay on the air traffic control display and to the pilot via the Mode S data link.

o In addition to the program efforts I have just described, Dr. McCarthy of the National Center for Atmospheric Research, working with a group of technical experts, completed a report during 1986 which provided a number of recommendations covering the areas of pilot weather

training and near-term improvements in forecasting, particularly as they relate to severe weather hazards. The FAA will be reviewing these recommendations with a view toward implementation of needed improvements, particularly in the short-term forecast area.

Finally, because of the interest in aviation security, we are continuing research in advanced explosive detection systems for baggage and cargo inspection, improved concourse security through an integrated system, explosive vapor detection sytems for detection of explosives and flammable liquids carried by passengers, and the best methods of handling bombs discovered after the aircraft is in flight.

The FAA is developing and evaluating an advanced generation thermal neutron detection for baggage and cargo inspection. A chemiluminescent vapor detection system is under evaluation and will be combined with an existing passenger portal system in FY 1987. In addition, advanced detection concepts are being evaluated. Promising techniques will be developed and tested.

Mr. GEORGE BROWN. We are going to take one more witness before we have a short lunch break, and that witness is Dr. Walter Orr Roberts, who is the president emeritus of UCAR; a distinguished scientist and a gentleman who has made many contributions to the work of the Congress in the past, and we hope you will do so today.

STATEMENT OF DR. WALTER ORR ROBERTS, PRESIDENT EMERITUS, UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Dr. ROBERTS. Thank you very much, Mr. Chairman.

First of all, it is an honor to have the opportunity to testify before this distinguished body. Your parent committee, the Committee on Science and Technology, in my judgment, has played an outstanding role in bringing sound policy to science and technology in this country. And all of us in the scientific field are very grateful for the kind of support and guidance we have received. Moreover, the Aviation Subcommittee has taken steps to ensure that the preeminence of our country in aviation is maintained.

As you pointed out, Mr. Chairman, and several others, Denver is one of the very few large airports anywhere on Earth that is going to be completely rebuilt over the next two decades, built from the ground up. And as many people have said, this is a challenge, an extraordinary challenge for the future. And we are going to have to build an airport that provides comfort, safety, flexibility for growth, including the kinds of aircraft that the gentleman from NASA described for us; security against terrorism, ease and speed of access, economical construction and operation; and, in addition, it has got to be environmentally sound with respect to noise, pollution, and esthetics. This is not going to be an easy job.

It is going to require cooperation from Government, academic institutions, from private research centers, and from industry. My plea is that this approach be done in an integrated systems manner, using modern tools of management and planning.

Our own organization, the University Corporation for Atmospheric Research—UCAR, as we call it—has contributions to make in the most important areas of air operation, namely safety of arriving and departing aircraft from weather hazards. And of these, as several have mentioned already, wind shear, is one of the most serious and dangerous—wind shear, particularly that resulting from the recently discovered phenomenon of the microburst or downburst. According to the best estimate, a score of jet aircraft have crashed over the last two decades because of microbursts. And many many times this number has been at risk. As traffic densities increase, the number of such crashes will increase unless additional preventive measures are taken. And, indeed, they can be taken; the technology exists now.

UCAR, our corporation, is a consortium of over 50 United States and Canadian universities or research centers that not only do research, but have advanced academic programs. And we operate the National Center for Atmospheric Research [NCAR], which you visited, Mr. Chairman, which has taken a lead in the study of microbursts and in the analysis of wind shear. We have done this in cooperation with the FAA and with the support of FAA; in collabora-

tion with NOAA, Lincoln Laboratories, and with the private sector. And we feel that to do this job over the next 20 years in the right way is going to take enormous collaboration among all these different partners.

UCAR plans to be a major player in the protection of Stapleton Airport of the future against microbursts. We already have several years of experience in active operational tests involving terminal Doppler radars. And I have invited my junior colleague, William P. Mahoney, to say a few words about the work we have done on microbursts in just a moment.

We believe that the system that we are going to be able to develop using terminal Doppler radars, together with the low-level wind shear alert system—the LLWAS, as it's called—we believe that this will also allow us advanced detection of another type of wind shear that results from what we call gust fronts, that make it necessary to change the runways; and through this, we expect we will be able to give advance planning to the controllers so that runway changes can be made in a systematic way and greatly improve the efficiency of the use of the runway structure, and thus increased volume, safely. We may be saving enough money in fuel to pay the entire cost of the development of the system.

But the airport of the future must not stop with these safety and efficiency improvements. A rare opportunity exists here to build an airport that will be a show piece for the entire world. To do it, we are going to have to avoid temptations to do it in a piecemeal, patch-work way, because neither of these things will bring us a cheaper or an easier solution.

UCAR, our corporation, has just created a subsidiary, not-for-profit foundation. And I have just accepted the position of president of the organization. And Najeeb Halaby, former FAA Administrator, has been named as chairperson of our new foundation.

We are prepared to use the mechanisms of the UCAR Foundation to mount major, high-technological enterprises in the interest of our member institutions and in cooperation with Government and industry wherever it will benefit the Nation. And I am convinced that our foundation can play an important role in the prompt and effective development of the airport of the future at Stapleton. We are ready to launch a conceptual study of the potentialities for this airport. John McCarthy, Mahoney's boss, and I will be calling as early as next month for participation from all sectors in the country in a brainstorming seminar, supplemental to George Doughty's excellent planning effort, that will come up with a checklist of necessary design requirements, with particular emphasis on weather protection, that will make the future Stapleton the best and safest major airport in the world.

I would like now for Mr. Mahoney to say a few words about microbursts.

Mr. GEORGE BROWN. You have given us a challenging introduction. We welcome Mr. Mahoney.

STATEMENT OF WILLIAM P. MAHONEY, UNIVERSITY CORPORATION FOR ATMOSPHERIC RESEARCH

Mr. MAHONEY. What I would like to do is give a very brief slide show of what a microburst is and what kind of programs we have run to predict and detect microbursts.

A microburst is just a downward flow of air that comes out of a cloud. It hits the ground and spreads out at the surface, just like you would have if you took a garden hose on the ground and let it spread out. What it does to an aircraft is; initially, the aircraft will experience a head wind, a performance increasing head wind, which would cause the aircraft to lift. The pilot then would probably push the nose down to get back on the glide slope. A few seconds later he will experience a very strong down-draft, and a strong tail wind as much as 90 knots in the worst case.

This type of loss of lift can cause the aircraft, and has in the past, caused the aircraft to crash.

This is an example of a microburst vortex. The microburst would be on the right side of the screen. The air hits the ground, spreads out, and curls up. This is a very dangerous wind shear situation, much like the wind shear that caused the Dallas crash last year. And, again, you can see in the background that the clouds are very benign. A pilot would not think twice about flying in and near those type of clouds.

Most pilots so far have been trained not to fly into a typical classical thunderstorm as pictured here, but, unfortunately, only about 50 percent of the microbursts occur in thunderstorms. The other 50 percent occur in conditions that I showed before, where you have very benign clouds.

This is an example of a microburst that occurred over Stapleton in 1982. You see a very light rain shower over the ground. The rain did not even hit the ground. And yet at the airport they measured approximately 65-knot wind shear from one end of the runway to the other.

This is another example at Stapleton. You see a light rain shower or moderate rain shower off in the distance. The air hits the ground and curls up and causes a severe wind shear. I believe there is about a 70-knot wind shear across this event.

This picture shows an example very much like the rain shower that likely downed the aircraft in Dallas.

This is another example you would see when a microburst hits the ground out West. This is near Stapleton in 1982. Again, there is no precipitation with this microburst; it has all evaporated well above the ground. It does not appear to be a hazard. But then, again, there is a 50-knot shear wind blowing across the ground, picking up a lot of dust. This is a very dangerous situation for an aircraft leaving or approaching an airport.

Again, another example of the blowing dust, this microburst hit center field just next to the tower at Stapleton in 1984. They had to close the airport in this case because there was approximately a 72-knot wind shear from one end of the runway to the other. A very dangerous situation for an aircraft that is not aware that this is going on.

One more example, you see a line of microbursts occurring. And in that line, in the middle there, you see a dark spot, which is a gust-nado—a tornado that is kicked up by a passing gust front; and the little white speck that is right ahead of that is an approaching 727 that flew right through that gust front and microburst and tornado, and reported severe turbulence. Very lucky that did not happen a few hundred feet closer to the touch-down point.

Some microburst statistics: the maximum shear that we usually see with first detection is 24 knots. A few minutes later, approximately 5 minutes after the microburst hits the ground, you will see approximately 47-knot to 50-knot wind shear maximum. And the distance across the entire feature is only about 1 to 2 nautical miles. Very small, very intense, and very dangerous.

Some statistics for Denver-Stapleton Airport, the majority of microbursts occur between 1 in the afternoon and 6 at night, with the mean being somewhere around 3 in the afternoon, which is the time of maximum heating. You may want to avoid, in the summer time, avoid flying into this airport at that time.

The distribution of shear intensity at Denver-Stapleton Airport. Approximately 30-knots wind shear is the least we find with microbursts that hit the ground. We have seen microbursts of over 95 knots, shear, across the feature, going 3 or 4 miles across. The average wind shear for these features is approximately 45 knots. Forty-seven-knot wind shear is what caused the New Orleans plane to crash, and that is only the average wind shear a microburst often causes. There can be—I think it was a 69-knot wind shear that caused the Dallas flight to go down. As you can see, there are a lot of wind shears in the dangerous category, and then there have been some detected over 100 knots.

This is one bad example of something that happened in 1982 during the joint airport weather studies project. which was a research and development project to detect microbursts. There was no communication with the tower at this time; it was strictly R&D. By this point in time, there were four microbursts within 10 nautical miles of the airport. The horizontal and vertical lines in the middle are the runway configuration. At approximately 2:10 p.m., four aircraft were on approach, heading west to land. The first flight, 244, which is Frontier, flew through a microburst, had to abort its landing, came around and tried again at 2:15; again, severe turbulence. He could not control the aircraft and had to abort. Two other aircraft tried the same thing and could not land the aircraft.

At that point in time, the air traffic controllers decided to change runways, because they were not sure what was going on at that end. They then started approaching the aircraft and landing them to the east. One of the aircraft flew through another microburst that was off the west end of the runway, and another aircraft coming in flew through one, that was heading off the north end of the runway. At that time, they decided that approach was not safe, and they changed the pattern to fly toward the north. Again, another microburst occurred, and the aircraft had to abort. And two other aircraft went ahead and flew through the thing because they did not know it was there; reported severe turbulence.

This situation—it was almost a miracle that nobody got hurt, with all those aircraft coming in at different directions, all experiencing severe microburst wind shear.

The low-level wind shear alert system was put in place to detect gust fronts, which is a wind shift line. Unfortunately, what happens is that a microburst is small enough that a lot of times they land between the wind sensors, which are located around the airports. This system is designed so that if a number of sensors sense the winds coming from a different direction, an alarm will go off and the pilots will be warned that there is a wind shear in a certain quadrant of the airport. Unfortunately, it does not at this time, detect microbursts very well. There are some research and developments going on that will improve this system significantly.

At this point in time, because of the joint airport weather studies project in 1982, a terminal Doppler weather radar is now being tested. It has been shown that Doppler radar can detect microburst wind shears. And this program, which placed a Doppler radar at Stapleton Airport in 1982, was very successful in detecting microbursts.

This, without going into an explanation, is a display of what a Doppler radar looks like when it sees a microburst wind shear. The blue colors are winds heading towards the radar at approximately 30 knots. The hot colors, the orange and reds are the wind speeds heading away from the radar at approximately 30 knots, indicating a nearly 60-knot wind shear over a distance of about 3 or 4 miles.

This again shows that Doppler radar is very good at detecting microburst wind shear.

United's Flight 663, May 31, 1984, was leaving Stapleton on a departure and hit a microburst of approximately 50-knot shear. There was rain falling, but it wasn't hitting the ground; we call that virgia. There was no thunder. A pilot ahead of him reported a wind shear of approximately 20 knots. There was blowing dust on the ground. The low-level wind shear alert system was going off, but nobody was quite sure what type of wind shear they had. They just knew they had a wind shear.

A new technique developed by United and Boeing was used by the pilots to trade his air speed for altitude, and it was because of that new technique that has been developed, because of the research, that the airplane did not hit the ground.

Because of that accident, the FAA asked NCAR to do a prototype study at Stapleton, using a Doppler radar that was in place for another reason. And what it entailed was taking the data that the Doppler radar was using, placing a metereologist in the tower; and when the radar saw a microburst within 5-nautical miles of the airport, the tower metereologist was notified, and he then drew a picture of where the microburst was, its intensity, and this information was then passed on to the pilots.

At the same time, questionnaires were filled out—I'll jump ahead a second. Questionnaires were filled out by the pilots after they received the wind shear warning. This is one testimony by a pilot who was warned that there was an approximately 55-knot wind shear on his approach. He was a heavily loaded 747 in a critical phase of approach. He stated that just knowing that the wind

shear report was given to him, it saved his aircraft from being forced into the ground short of the runway.

The first line of defense, then, from all these different R&D approaches we have taken, and from the new terminal Doppler research that we are doing now is to absolutely avoid wind shear at all costs. What this entails is delaying takeoff until conditions improve. Once you are in flight, divert around the area of known wind shear. And, No. 3, if wind shear is indicated during the approach, initiate a go-around or hold until conditions improve.

If an aircraft happens to fly into a wind shear and does not know it, some new training techniques—as I mentioned before—are being used, in which the airplane will pull up to the stick-shaker; go max thrust, and stop rotating before the aircraft stalls. This has worked in the simulators very well; and, again, saved the aircraft in Denver in 1984 from going into the ground.

On the third line of defense, then, is what we are working on right now, improved detection, and improving the low-level wind shear alert system by increasing the number of sensors and increasing the number of mathematical algorithms to detect where the wind shear is going to occur, what type of wind shear is going to occur, and how intense the wind shear will be. Also, right now it has been seen that the terminal Doppler weather radar can detect microbursts, tell where they are, and what kind of severity they will have. And we are at the present time working with the FAA and MIT-Lincoln Laboratory to develop this terminal Doppler weather radar, which should be in place, hopefully, in the next 3 or 4 years at a number of airports.

The final thing, then, is research on airborne Doppler radar, which will probably be well down the line in 5 or 10 years, in which each aircraft will then know what kind of wind shear it has ahead of it.

That is all I have, Mr. Chairman.

Mr. GEORGE BROWN. Dr. Roberts, I am surprised that NCAR has not been able to come up with some research that would allow us to eliminate wind shear, not just detect it. Are you working on that?

Dr. ROBERTS. I think we can eliminate accidents caused by wind shear. I think that is clearly within the prospects if we employ Doppler radars at the major airports and improve the low-level warning system. I think we can avoid them; get a 3-minute or 4-minute advance warning of the dangerous one, and protect the aircraft with an almost perfect assurance.

Mr. GEORGE BROWN. What is the problem with using the airport Doppler radar with getting the message to the pilots in a timely fashion that would produce the necessary action? We are talking about a very brief phenomenon here, at a time when a pilot has a lot of other things on his mind and all sorts of things of that sort.

Dr. ROBERTS. This is going to take a great deal of work. And that is one of the things we will be looking at, assuming that we deploy this system next summer, as we plan; to present the information in a manner that will not saturate an already-busy pilot with things to do, but at the same time will give him a completely reliable warning. It involves new kinds of computerized display systems. It involves, probably, training of the people in the tower. And it also

involves training of pilots about the hazard of wind shear. And all of those things are going on at the present time, the training and planning.

Mr. GEORGE BROWN. This new foundation that you spoke about that you and Mr. Halaby are going to be involved in, explain in a little more detail what the service is that the foundation will provide. Is it an effort to provide a more direct link between the fruits of NCAR's research and the needs of aircraft and airport designers? What is the theory behind it?

Dr. ROBERTS. Yes; exactly that. Many of the areas of NCAR's research have very substantial economic and safety benefits potential out there in the future. NCAR, itself, is basically a fundamental research organization. And the fruits of this research, we feel need to be translated as quickly and effectively as possible into operation, which has not been UCAR's and NCAR's business in the past.

And so we hope, in collaboration with private corporations, for-profit corporations, and the like, to bring the exploitation of that basic research to practice in new ways. And we are expecting that some of these will bring revenue to the UCAR Foundation, which we will then plow back into research, giving us alternative sources of income for fundamental work.

Mr. GEORGE BROWN. You know that we have been preaching the gospel of more effective technology transfer for a long time. We hope that a mechanism such as you are planning here will demonstrate new and more effective ways to accomplish that. If it does, it will be because of NASA, FAA, and all these other organizations.

Dr. ROBERTS. That, indeed, is our hope.

Mr. GEORGE BROWN. Mr. Packard.

Mr. PACKARD. Thank you, Mr. Chairman.

Dr. Roberts, has UCAR or NCAR been doing anything in terms of airborne detection of wind shear?

Dr. ROBERTS. No. We have not done any direct research in airborne detection, but we have kept ourselves thoroughly informed of the work that is going forward at Boeing and other places.

Mr. PACKARD. Sperry?

Dr. ROBERTS. And Sperry.

We have done the work to describe the physical mechanisms of the microburst. And that is being used by these airborne detector development groups. Our model, they use in order to know what to look for. We, ourselves, do not do any airborne Doppler research.

Mr. PACKARD. What kind of dialog have you had with Stapleton officials and those that are designing new airports? Have you had any dialog in terms of your research?

Dr. ROBERTS. Yes. We have been in close touch with the New Airport Development Office. And we hope to carry cut this brainstorming session next month, or very soon, with the support and help of the New Airport Development Office.

Mr. PACKARD. Has your research gone far enough to determine how wind shear affects different kinds of aircraft, small general aviation or propeller-driven, helicopter, some of the new designs that you are seeing today? Have you gotten any idea as to whether some aircraft are more drastically affected than others?

Dr. ROBERTS. Yes. We have done a great deal of research on that. It turns out that the airplanes that are vulnerable to wind shear of

the microburst type are the ones with very high wing loadings; small wings and large weight. This means jets. But anything from a Lear Jet on up to a 747 is vulnerable. And it is partly because there is a natural period of oscillation of an airplane, called the phugoid, which is a function of its wing load. And the phugoid of a jet airplane happens to be just exactly wrong to make it vulnerable to a microburst. It has got a phugoid of 20 seconds, 30 seconds; and that is just the length of time from the head-wind to the tail-wind segment. So a propeller plane, like my Beech Baron, will not suffer anything except severe turbulence; no real hazard in a microburst. But a jet will not be able to make it.

Mr. PACKARD. It would be interesting to see if the X-wing or the tilt rotor would—what effects that would have. But perhaps that is research for the future?

Dr. ROBERTS. That is for the future.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Mr. Mahoney.

Mr. MAHONEY. I was going to mention that at the present time all the numerical models we have come up with from our research at NCAR are going to anybody who wants it, and the different organizations that are developing aircraft types and planform types are taking that information and putting that into their simulators; then they can test ways of flying out of these for different types of aircraft, depending on what their simulators are geared up to.

Dr. ROBERTS. We have also prepared a short video tape, with the cooperation of the FAA, with the support of the FAA, to show to pilots to indicate if you get into one, what are your best chances of getting out.

Mr. GEORGE BROWN. Dr. Roberts, do you have a prospectus or anything of that sort of this new foundation which you have described today?

Dr. ROBERTS. Mr. Chairman, the new foundation was only created on July 14, and we are drafting a brochure and explanation. But we will have one within a month or so.

Mr. GEORGE BROWN. If you could supply the committee with just a little tidbit of information, we would be very interested.

Dr. ROBERTS. I will be glad to do that.

Mr. GEORGE BROWN. Gentlemen, I think that will be enough for this morning. We thank you very much for your contribution. And I really am hopeful that NCAR and UCAR will be able to develop this close working relationship, nearing the design of the airport, because I think it would be extremely valuable and help set a model for the entire country in airport design.

Mr. PACKARD. I would be interested, Mr. Chairman, in simply asking, are there other agencies that you are aware of that are doing similar studies through the country, or the world for that matter, on wind shear?

Dr. ROBERTS. First of all, UCAR represents over 50 research institutions in the academic field. And many of those institutions have important work. The University of Chicago, for example, under Dr. Fujita, have done analyses of the Dallas-Fort Worth and New Orleans microburst crashes. We work very closely with them. Then there are a number of other institutions and organizations,

the FAA, NOAA; NASA has microburst research. We are in very close collaboration with all of them.

Mr. PACKARD. Thank you very much.

Mr. GEORGE BROWN. But NCAR represents the cream?

Mr. ROBERTS. We like to think that.

Mr. GEORGE BROWN. Thank you very much, gentlemen.

The subcommittee is going to recess for about an hour while we have a little lunch. The remaining three witnesses will be invited to appear beginning at 1:30, approximately. And we hope to finish up by 3.

[The prepared statement of Dr. Roberts follows:]

House Committee on Science and Technology -- Page 1
Subcommittee on Transportation Aviation and Materials
28 July 1986 10:00 AM, Room 3211, Stapleton Airport

TESTIMONY OF
WALTER ORR ROBERTS

I appreciate greatly the invitation to testify before this distinguished body. The Committee on Science and Technology has played an outstanding role in shaping the policies of our nation in science and technology. Few areas of activity are more important to our national economic and social health. Your committee has helped enormously, over many years, to build scientific preeminence for our country. Moreover aviation is a field of science and engineering in which our private and public sectors have gained world leadership.

Denver is the site of one of a very few large airports anywhere on Earth that will, in the next two decades, be rebuilt from the ground up. This presents us with a challenge to create a prototype airport of the future--an airport that will serve as a model for all the world--an airport that will be the world's best. We must apply the utmost in high technology to all aspects of the airport design. The new airport must provide passenger comfort and safety, flexibility for growth, security against terrorism, ease and speed of access, economical construction and operation, and it must be environmentally sound in terms of noise, pollution, and aesthetics.

To bring to real life all these ideal qualities will be no easy task. It will demand cooperation of government, academia, private research centers, and industry. My main plea is that it be done in an integrated systems manner using modern tools of management and planning.

Our own research organization, the University Corporation for Atmospheric Research (UCAR), has important contributions to make in one of the most important areas of air operational safety--namely the protection of arriving and departing aircraft from weather hazards. Of these, perhaps the most important is wind shear resulting from a quite recently discovered phenomenon, the microburst or downburst. A score of jet aircraft have apparently crashed in the last two decades because of microbursts. Many times this number have been at serious risk. As traffic densities increase, the

numbers of such crashes will also increase unless additional preventive measures are adopted--and they will be.

UCAR is a consortium of over 50 U.S. and Canadian member universities or centers with research programs in atmospheric science and related fields. Each of the members has active weather-related scientific work in progress, along with related advanced degree educational programs. We also operate the National Center for Atmospheric Research (NCAR) which has taken a lead role in microburst and wind shear analysis. Other research centers, like NOAA and the FAA in government, and Lincoln Laboratories in the private sector, have also made major contributions to this subject. In addition the private industrial sector also has high skills to contribute. To do the job right will take collaboration amongst all of these.

UCAR plans to be a major player in the protection of the new Stapleton against microbursts. We have already had several years experience with these phenomena at Stapleton and elsewhere. Next summer we plan an active test operational protection system involving Doppler radars and advanced low level wind shear sensors. My colleague, Bill Mahoney of NCAR, will describe some of our work on microbursts in just a few minutes.

We believe that our system also will provide improved advance planning of runway changes, through prediction of the time of occurrence of wind changes produced by passage of gust fronts--discontinuities in wind flow detectable at some distance with our Doppler radars. The consequent improvement of flow control into the airport should increase the volume of traffic that can be safely handled, and should prevent lengthy delays in the air, thus saving millions of dollars in fuel consumption.

But the airport of the future must not stop simply with these weather safety and efficiency improvements. A rare opportunity exists to build an airport that will be a showpiece of efficiency and customer convenience for the entire world. To do this will take imagination, high technological skills, systems management expertise and determination not to succumb to the temptations of a piecemeal, patchwork job either in the name of economies or timidity, for neither will be cheaper or easier in the long run.

UCAR has just created a subsidiary not-for-profit foundation and elected an outstanding national Board of Directors. I have accepted its presidency, and Najeeb Halaby, former FAA Administrator, has been named

as Chairperson. We are prepared to use the mechanisms of the UCAR Foundation to mount major high-tech enterprises in the interests of our member institutions and in cooperation with government and industry. I am convinced that the Foundation can play an important role in the prompt and effective development of the airport of the future at Stapleton--and we are now ready to launch a conceptual study of the potentialities. We will be calling, as early as next month, for participation from all sectors in a brainstorming seminar to come up with preliminary definitions of design requirements for the world's best and safest major airport.

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AFTERNOON SESSION

Mr. GEORGE BROWN. The gavel goes bang bang, and the subcommittee will come to order.

This afternoon, we have three witnesses who will have a great deal to contribute to our hearing this afternoon. The first is Mr. William B. Rourke, who is chairman of the board of the regional transportation district. And we are very pleased to have you here and look forward to your testimony.

Mr. Rourke, you may proceed. Let me indicate to you that we are trying to get through by around 3, maybe a little later. That leaves each of the three witnesses with about 20 minutes or so, including questioning. And so will you please try to keep within that timeframe and help us out a little bit? Thank you, sir.

STATEMENT OF WILLIAM B. ROURKE, CHAIRMAN OF THE BOARD, REGIONAL TRANSPORTATION DISTRICT, DENVER, CO

Mr. ROURKE. Mr. Chairman, members of the committee and staff, I thank you very much for the opportunity to be here to talk to you about what I think is a fairly novel approach to our airport planning. And an opportunity has been given to me by the airport director, George Doughty.

On a recent trip to Washington, DC, to testify before the House committee, Representative Layman chairing, and the Senate committee, Senator Andrews chairman, I used WAMATA to go from Washington National Airport over to the House and Senate Office Buildings. I have an indication of the enthusiasm for which some of the people here in Denver encourage us to build a rapid transit system from downtown to the airport, the new airport.

It is interesting to note, however, that the figures vary from 5 to 7 percent of all of the passenger traffic in Washington National Airport uses WAMATA. Even though more than half of the passengers to and from Washington National Airport are, in fact, destined to or origined from downtown; and, thus, the comments I will make today.

Virtually all of our airports in the United States today, perhaps Washington Dulles being the single exception, simply replicate the concept of airports inherited from the 1930's. When I was a youngster, my father would take me out to Chicago Midway Airport to watch the airplanes. The idea being that we can drive up to the curbside, walk through a very short distance in the terminal building, and make direct access to the airplane.

I am proposing to direct our attention to the landside of the airport and how we can address the needs of the passenger in a systematic, functional way of looking at, first of all, who are the passengers that need to be aided, and then what are their needs.

An airport, quite briefly, is simply a facility that enhances or makes easier the opportunity of people to use a transportation system. And in order for us to accommodate those people in that facility, we need to have a high quality, through-trip service. Now, that means we need to know origin-destination characteristics or demographics of the passenger who travels to the airport. We also need minimal travel time and transfer. And, indeed, the reduced

transfer. The biggest delay is right here in the terminal building between the curb and the gate. And then, third, cost sharing.

Indeed, if we are going to use air travel in facilitating or expediting the efficiency and effectiveness of getting people to and from the airport, that is a consideration of air pollution, it is a consideration of fuel economy. And Denver air pollution is very important and fuel economy, nationwide, is very important. So this is a public benefit, and I think cost-sharing is appropriate, that it be funded at least in part.

Now, let us look at the demographics of the people who actually use this terminal building. If we were to go outside in this concourse today and inventory people, you will find that two-thirds of the personnel who are using this terminal today are meeters and greeters; they are not going anywhere and they did not arrive from anyplace. It is mom and dad coming down to meet grandma, that kind of a thing. In fact, only one-third of the terminal users here at Stapleton are actually passengers that are going to travel or have traveled on aircraft.

Now, let me contrast that, if I may, with Orlando, Orlando being the access gateway to Disney World, where clearly the overwhelming majority of passengers that use the Orlando Airport are going to get off of that airplane, go through the terminal, and then will require some form of ground transportation to Disney World, and the reverse for their return trip.

Of the one-third of the people that use this terminal now, who actually are air passengers, three-fifths of them, because Denver is uniquely a hub airport, do not require any landslide services whatsoever. These are people that came in from Chadron, NE and they are going to transfer to a United flight going to Hawaii. So they really need transportation from one gate in the terminal to another gate. And that is the result of Denver being a hub airport.

The final two-fifths of those one-third of the people who are in this terminal building are those who are primarily residents of our Denver regional area, not businessmen. Their origin, in fact, is home.

Now, as chairman of the RTD, I had a requirement to focus considerably on an airport-downtown connection. But, in fact, the focus on the airport as requiring service from the central business district is simply unfounded.

Second, in fact, if we were to acknowledge a need from the Denver central business district, then we need to consider that very shortly another major employment center—the Denver Tech Center Complex, the Denver Tech Center, Inverness Green, Greenwood Plaza and so forth-will soon equal the central business district as an employment center and, thereafter, will surpass it. So we actually have two, and, indeed, by the year 2000 we will have six employment centers in the six-county, regional area, all of them having employment above 50,000; again, emphasizing the fact that the central business district focus is simply unfounded.

That would seem to indicate, then, that there is a need for a rather circular transit system around the Denver area that dominates within the residential area, but certainly does go through the terminal building, and I mean through the terminal building in the

same concept as the monorail goes through the Contemporary Hotel in Disney World.

Let me reprhase, then, the demographics, if I may, in terms of fifteenths, so we can get a direct comparison. Ten-fifteenths of the people that use the Stapleton Airport terminal building are meeters and greeters; a simple policy decision that says nobody can walk through the door unless they have a ticket would instantly evaporate our terminal problem.

Three-fifteenths of all of the people who use the terminal at Stapleton are airport users who are in transit; they do not require ground-side services. The other two-fifteenths are made up of regional residents from our six-county area, tourists who are coming in, both summertime and wintertime; and then Denver area residents. Later on, I will show you how the influence of seasons influences the nature of the needs on the ground side.

The private automobile provides 56 percent of the transportation mode for people to gain access to our Stapleton terminal. Government or company cars, but, again, an automobile, an additional 1 percent. And then the rental car provides an additional 18 percent of the means of egress and ingress to the airport.

Adding that up, 75 percent of the mode of transportation to get to or depart Stapleton Airport terminal is made up of a private automobile of one kind or another, and yet those 75-percent vehicles move only one-third of the actual passengers that use Stapleton as a terminal.

In 1985, of the 627,000 car rentals that were engaged in, 326,000, or more than half of them, occurred from the 15th of November to the 15th of March, and dominantly in the December-January-February; again, giving a clear indication of the kind of functional services we need to provide to the citizen who uses our terminal.

The rest of the four categories of airport users presently generate about 28.8 million annual passenger departures from Stapleton, and of that only 10 percent of 2.8 million utilize all of the available forms of mass transit, including courtesy vans, shuttle buses, public transit, the buses that the RTD operates, and charter buses.

I have detailed for you some of the functional characteristics of transportation modes in a to-from, to get people to and from the airport. The passenger in mass transit is driven to the main terminal; then he often has to make a transfer to another airline terminal, such as occurs in Seattle, where you go to the north or the south terminal; in Houston, where you take the underground mobile railway to get out to one of the concourse elements; or in Orlando.

As I have noted, at Washington National Airport, less than 8 percent of all of the airport users employ the Metro, WMATA, even during periods when the parking lot is full and even though more than one-half of all of those airplane passengers are going to or they came from the downtown area.

In Chicago at O'Hare Airport, they have managed to get a somewhat larger percentage ridership on the heavy rail traffic there. And that is predominantly the result of some very difficult automobile access to and from O'Hare Field.

Another characteristic of our airports in the United States, again stemming from the thirties, is that we have a horizontal layout.

We might contrast that with Zurich, Switzerland, which has a vertically integrated airport; the top level containing concourses where passenger loading and unloading takes place. One level below, we have a baggage claim area, banks, hotel reservation booths; and an interesting feature there, where you can actually indicate your baggage is to go to a single hotel, and then a private enterprise person picks up your baggage and then takes it to that hotel. Then the next level down provides all the transportation linkages—trains, car rentals, and buses—and most of the passengers do use public transit.

To facilitate the intraairport movement—that is, within the airport, then—we need to analyze some of these functional needs. For instance, intraterminal transfer from one carrier to another, that is to say, from gate to gate—and I think all of you have been through O'Hare Airport, and your secretaries probably make a concerted effort to make sure that you do not have to go from the end of one concourse to the end of another.

Then you have from parking, or the curbside, to the ticketing counter to the gate; from parking or curbside, directly to the gate. There might be an interterminal transfer needed. And those of us who have landed at Los Angeles know some of the complications that can occur in the sterile concourse concept; the difficulty of simply having a security function set up within an airport. And then we have to reverse the flow from the aircraft gate back outward again, to the home where the person is going.

Terminal gate areas, that is, on the air side in the terminal, are widely spaced in order to minimize aircraft taxi time, maneuvering difficulty, and the attendant costs. Passengers, on the other hand, require that the space between the terminal gates and parking or car rental and the check-in be minimized in order to save walking time and effort. The intraterminal transfers, making up 67 percent of the passengers arriving at our airport, results in a severe extension of walking distances, congestion, and an overall rise in airport operating costs.

At Atlanta, Seattle, and Orlando, the Westinghouse Corp., has secured most of those orders. MATRA has now received the contract and is installing an interterminal system at O'Hare Field. Most of these are large vehicle systems, of 40- to 120-passenger capacity, and quite costly because of the guide system that is required to support these vehicles. They require large, heavy, costly guideways. That invariably means Federal subsidies because it is simply impractical to charge a fee for a very short ride when you have given people essentially no other alternative.

Large vehicle systems currently are limited to line-haul operations. That is, if I want to stop at one particular place, everybody on board is going to stop with me.

Systems that did offer some measure of route flexibility and offline station capability, such as the Boeing people mover, which is at Morgantown, or the LTV Air Transit System at Dallas-Fort Worth, they are no longer being marketed. And, in part, they are high-cost, which is the reason for that.

The current people movers are simply unadapted to airports for some of the following reasons: One, only passengers can be carried; it is not really convenient to be carrying your suitcase down the

concourse in Atlanta, go down the escalator, get on the people-mover, ride through the tunnel, back up on the escalator, and outside. And even the FAA, noting this, has put a restriction of approximately 1,000 feet walking distance as a guide for terminal development and design.

The car rental companies are not well served by a single common station in their service areas. The result is they buy buses. Now, the buses themselves add cost to your car rental and they tie up—additional traffic congestion—out here in the front end and the land-side of the airport.

Parking lots may be served by one or more stations, with significant additional costs, but the walking distances are still great. Freight cannot be carried on these kinds of systems. Off-line stations are simply mandated; they are required in order to handle freight to and from aircraft. Food services and other airline services, likewise, cannot be accommodated. Baggage cannot be accommodated. In an era of frustration with that monkey that reaches out and grabs your Samsonite and tests it, more and more of us are carrying on board baggage. And this is a need that should be identified.

Earlier this week, I went to Boston, Logan Airport, and I tried using MBTA, the "T" system. And by the time I got to one of the Back Bay hotel areas, I was exhausted, just carrying the baggage through.

As a result of limited service capabilities, the large vehicle system, the airport design must still be arranged to allow for conventional access, mobility to buses, automobiles, vans, trucks, container trains, baggage trucks, and so forth. So what we have available today simply does not answer what is needed, if we look at the demographics of the people who are using the terminal building.

Denver Stapleton Airport is one of the busiest airports in this Nation, and it is the world's seventh busiest. Increased air travel in a deregulated market has clogged operations at Stapleton, so that now it is second only to Chicago's O'Hare Field. Stapleton was built only to handle passengers that were arriving and leaving from the city. Suburban sprawl was simply nonexistent at that time, and deregulation, of course, has introduced the hub-and-spoke concept, which has changed drastically the characteristics of service on the air side and, thusly, service on the land side.

Now, United and Continental Airlines, operating hubs in Denver, generate about 80 percent of Stapleton's passenger traffic. We need an internal passenger, baggage, freight, small vehicle people-moving system rather than a large capacity, guideway system.[1]

I have added some data on the resulting problems: Parking, curb side, standing, and so forth; but my emphasis is simply to indicate that we are taking advantage of an opportunity provided here by George Doughty and his new airport design group, in order to design an airport that is based on the functions that this terminal building must serve.

I want to thank you again for coming to Denver. I think you can appreciate some of the problems we face here. And, hopefully, this

[1] Theoretical and practical hardware transit technology has been devised by Professor Ed Anderson (University of Minnesota, Boston University) CED TAXI 2000 Corp.

new approach will give us an opportunity to come up with a better design to service the people at Stapleton.[2]

Mr. GEORGE BROWN. Thank you very much, Mr. Rourke.

I am going to be very interested in what kind of a product comes out of this functional design. We have mentioned this morning the need for—I think the reference was integrated system design for the whole thing. And, obviously, you are echoing that——

Mr. ROURKE. Yes, sir.

Mr. GEORGE BROWN [continuing]. As it relates to those aspects which you are responsible for.

You made some remarks about the design at the Dallas-Fort Worth Airport, and some of the others, as to the problems that they have encountered. Can you expand on that a little bit? What do you regard as the main flaws in that design at Dallas-Fort Worth, which I see that they are doing a lot of remodeling on, anyway.

Mr. ROURKE. Yes. I brought along with me, if I might, because I think he can add some significant technical detail to this, Mr. Dick Bauman; who is the head of our planning and development section of the RTD. Would it be all right for him to come to the table and help me out with this?

Mr. GEORGE BROWN. Certainly.

Mr. ROURKE. I think one of the problems of the air trends at Dallas-Fort Worth, for instance, is that during icing conditions, the blue norther races down from the plains, and the system goes down because it doesn't have an electrical pickup to move it around, or it starts skidding tires on the track to move around.

Do you want to add some more to that, Dick?

Mr. BOWMAN. No.

Mr. ROURKE. In Atlanta, when I travel, I try making all of these intraterminal systems, and have taken a number of pictures showing people taking their bags, two bags in hand walking through the terminal to the central point, and then down the escalator, getting on the mover through the tunnel, going back up again. It is a significant chore for people.

Mr. GEORGE BROWN. I have that problem in Chicago.

Mr. ROURKE. Yes, sir.

Mr. GEORGE BROWN. I was intrigued by the description you gave of the airport in Switzerland. Zurich, is that it?

Mr. ROURKE. Zurich, Switzerland.

Mr. GEORGE BROWN. Is there anything like that feasible over here, or are we constrained to going to a type of vertical integration like they apparently have there?

Mr. ROURKE. Well, sir, I think it is only money.

Mr. GEORGE BROWN. Is that more expensive?

Mr. ROURKE. Yes, sir, I think it would be; excavating into the ground and bringing a mass transit system into essentially the basement multitiering structure. I would think it would be considerably more costly.

Mr. BOWMAN. I think you need to look at ideas like that for this airport because of the problems that Director Rourke pointed ou

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[2] As Professor of Aerospace Science, Metropolitan State College, I offer the resources of all of my courses to you, and your staff, to solve airport, aviation, and air transportation problems.

in the winter time. In the winter time here, there are approximately 175 different bus charters that work out of here going to the ski areas. The impact of ski and tourist traffic in the winter time is significant, and the handling of those charter buses right now, in addition to our buses with our regular transit fleet, it gets to be some fairly monumental traffic jams around the facility. And the difference you see in a facility like Zurich's, where the people and the buses come right into the terminal itself instead of having to walk across your major concourse, where all the taxis and pickup and dropoff is going on, is that you eliminate all that conflict between the pedestrian and the vehicle. And everybody walks a shorter distance, and the capacity of all the facilities is much higher because it is so much closer together.

Mr. GEORGE BROWN. Well, it is an obvious way to shorten distances, to compact them in three dimensions. This is what Los Angeles had to do when they remodeled for the Olympics; they double decked. They never dreamed that they would have to double-deck that airport. They thought they had all the space in the world, and it just did not work out.

There are obvious advantages to doing that, in terms of being able to bring different modes of transportation together without having to require an extensive cross-communication, cross-transportation of some sort. One reason more people at National don't use Metro is because you have to walk a few hundred feet. If the Metro system had been brought in underground to the airport itself—of course, the whole airport ought to be moved—if that could have been accomplished, you would find 10 times as many people using the Metro system.

Mr. ROURKE. Last May, we had the opportunity to ride the Luftansa train into the Frankfurt station; and, again, it went right into the basement, I guess you should say, and then up the escalator, and then you are right there in the concourse area.

Haneda in Japan, one can go from Shinjiku station on the monorail, and then the monorail terminates right in the station the airport station, terminal.

Mr. BAUMAN. It is much cheaper to do that on the front end, as a planned part of the facility, than it is to go retrofitted later on.

Mr. GEORGE BROWN. There is no question about that.

Mr. Packard.

Mr. PACKARD. One short question. In regard to the handling of baggage, to me that is another major stumbling block, both in checking in and picking up after flight. It would appear to me—and you have dropped the idea that there needs to be—and one of your sentences was that there needs to be, for the passengers, the ability to check baggage inside a parking garage. I see no reason why that could not be expanded to satellite check-in areas in the downtown or out in your new industrial park area, or wherever your geographics and your traveling public would go. It would certainly be a lot simpler for me if I could check in a few blocks away from Capitol Hill for National or Dulles, and then just go and take the Metro out and get on the plane and go; and then have the luggage delivered back to a satellite check-in point.

I think we could do a lot more with those kinds of concepts than what we are doing now. Frankly, luggage is another—it is a couple

hundred feet to walk from Metro stop. But the carrying and handling of luggage is another major impediment for people using the mass transit facility.

I think every city, every major city would be able to find a way to use satellite check-in points that would take a lot of congestion away from the traffic that burdens the front of the terminal and, of course, the problems of moving people quickly enough inside the terminal.

I don't have any questions.

Mr. BAUMAN. Again, to go back to that Zurich Airport, the facilities for the airport check-in and satellite and check-in are built into that system. If you are at the airport, if you are going to a hotel, you can check your bags directly from the airport to the hotel. When you are at a hotel, you can also check your bags directly to the flight that you want to catch at the airport. So that you see more and more people using transit because they do not have that burden of dealing with the baggage as they move from the airport into the city.

Mr. GEORGE BROWN. Well, I want to commend you for the approach that you are taking to this. I do not know whether I will commend the final product or not, but I sense that you feel the challenge that comes about from being able to design this system from the ground up, and to eliminate some of the problems that other airports have experienced.

Mr. PACKARD. One concern I have, Mr. Chairman, is that they will design some kind of a rapid transit system to accommodate this new design of an airport; then they will be back to my other committee, which is Public Works, and want some kind of funding for a mass transit system, which we don't have.

Mr. ROURKE. And your positive comments of support are greatly appreciated, sir.

Mr. GEORGE BROWN. All right, gentlemen. That will be all for you this afternoon. We appreciate your testimony.

Mr. ROURKE. Thank you, sir.

[The prepared statement of Mr. Rourke follows:]

Regional Transportation District

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TESTIMONY BEFORE CONGRESSIONAL SUBCOMMITTEE

ON TRANSPORTATION, AVIATION AND MATERIALS

William B. Rourke

Chairman of the Board

Regional Transportation District

July 28, 1986

Hearing on Airport Technology

Stapleton International Airport

Denver, Colorado

An Equal Opportunity/Affirmative Action Employer

TESTIMONY BEFORE CONGRESSIONAL SUBCOMMITTEE ON TRANSPORTATION, AVIATION AND MATERIALS

William B. Rourke, Chairman of the Board, Regional Transportation District

July 28, 1986

Forgetting the air traffic approaches, an airport may be functionally divided into the airside, the terminal, and the landside. My comments deal with the functions that must be accommodated within the terminal and on the landside--from the passenger approach, to the jetway.

While much has been accomplished in studying the functions needed by an airplane from its approach to the jetway, virtually nothing has been done to systematically determine the functions needed to facilitate the passenger or pedestrian approach, to the airport, through the terminal, to the jetway. Virtually, all U.S. airports replicate the 1930's desire to have every pedestrian drive to the curbside door of a terminal for a short walk to the waiting airplane. Dulles is the only U.S. exception. Terminals have become multi-billion dollar blocks to efficient functioning.

I wish to present a proposal for systematic functional design of Stapleton Airport, lest we repeat the acts of Atlanta and DFW.

It isn't Denver which is growing--it is the suburbs. By 2000, there will be as many people employed in the Denver Tech Center (DTC) complex as there are in the Central Business District. Employment in the DTC will continue to outpace. In the future, there will be six employment centers in the Metro Denver region, exceeding 50,000 employees. Currently, the CBD employs 110,000, while the DTC employs 60,000.

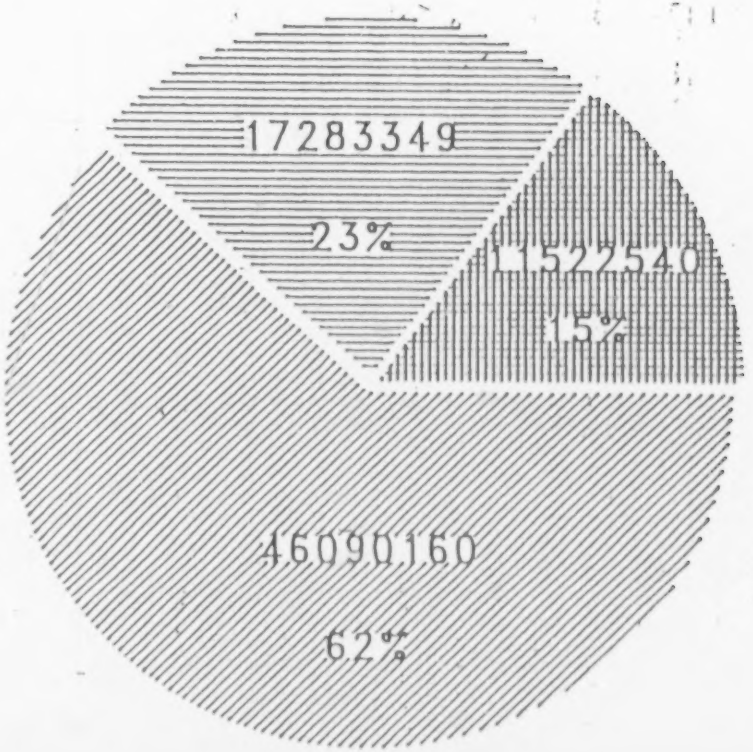
A successful rapid transit system needs more transit riders. We need to move people from where they are to where they want to go within the cost capability of our community (local, regional, federal) by providing:

a. High quality through trip service
b. Minimal travel time and transfers
c. Cost sharing

Two-thirds of the terminal users at Stapleton International Airport are "meeters and greeters." A policy decision to allow only ticket holders into the terminal would instantly solve the terminal "problem." Only one-third of the terminal users are passengers. Of the one-third that are passengers, three-fifths are using the terminal to get to other flights. They don't need transit, rental cars, buses, etc. The final two-fifths are passengers arriving or departing Stapleton and are primarily residents, not businessmen. Their origin is home. The focus on the airport as serving the Central Business District is unfounded. Soon, the Denver Tech Center will employ as many persons as the CBD, and in any case the traveling passenger's origin is his/her residence.

The obvious policy question raised is "should we continue to encourage greeters at the airport, which requires more parking, or should we discourage greeters and encourage alternate facilities such as suburban Park-and-Rides, Busways and Monorails?"

2/3 MEETERS/GREETERS
PARTING IS SUCH SWEET SORROW!



"Who uses the airport?"

10/15 Airport "meeters and greeters" creating disfunctional demands and almost exclusively using private automobiles.

3/15 Airport Users in Transit

Includes those transferring from one plane to another. Denver is a hub for two major airlines which board 80% of the passengers.

Regional Residents

Businessmen use cabs, rental cars and, rarely, public transit. Those from Boulder have good bus shuttle service, but most use private automobiles.

Tourists

Use buses (Charter or Business Operated)

2/15 Use rental cars (Winter skiing season)

Use cabs (Summer season)

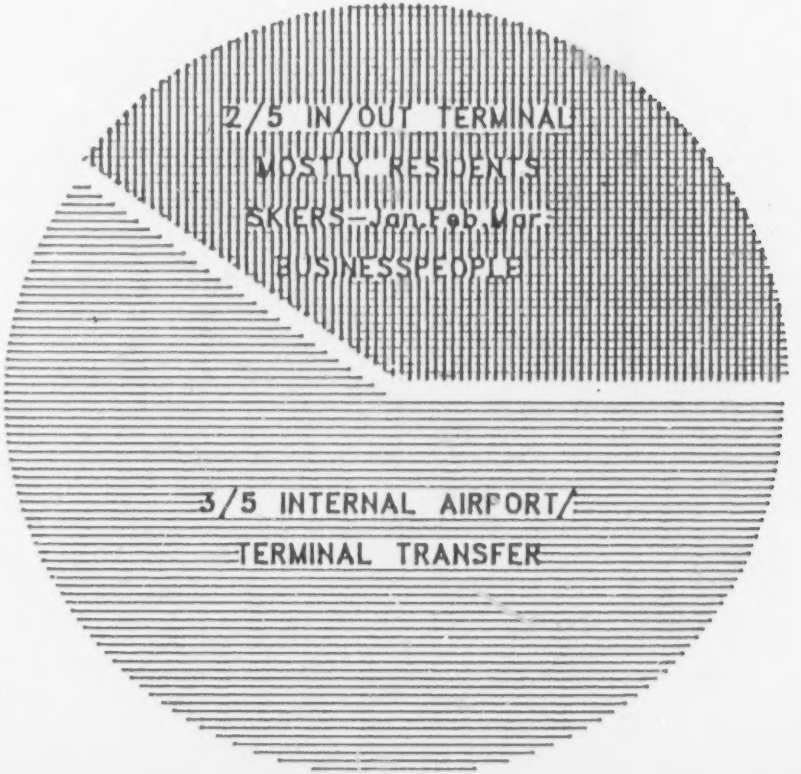
Denver area residents

Airport employees (Originate from residential areas using cars)

Airport users (Originate from residential areas using cars)

Airport visitors (meeters and greeters using cars)

1/2 ACTUAL AIRPLANE TRAVELERS



4

APPROXIMATE ACCESS MODE DISTRIBUTION

Private car	56%	
Company or government car	1%	
* Off-airport courtesy car	2%	
Rental car (Avg daily 1,700)	18%	(1985 - 627,000 rentals with 326,000 in Nov., Dec., Jan., Feb., Mar., for skiiers)
* Cab	5%	
* Motel/hotel courtesy car	8%	
* RTD	3%	
* Charter bus	1%	
* Airport limo	1%	
* Other	5%	

The private autos and the rental cars provide three-fourths of the vehicles approaching Stapleton, but deliver less than 30% of the passengers.

The four categories of airport users presently generate approximately 28.8 million annual passenger departures from Stapleton. Only ten percent or 2.8 million utilize all available forms of mass mode transport, including courtesy vans, shuttle buses, public transit, charter bus, etc.

5

PASSENGER MOBILITY REQUIREMENTS

Passenger Access and Egress to/from Airport

Mode - Automobile - Passengers and luggage driven to airport terminal by friend, relations, etc. - no parking required.

- Passengers and luggage driven to terminal - driver must park and return to terminal.

- Passenger drives to airport parking, then make trip to terminal.

Taxi - Passenger is driven to terminal with luggage.

Limousine - Passenger is driven to airline terminal with luggage.

Mass Transit - Passenger is driven to main terminal and must often transfer to airline terminal.

At Washington National Airport, less than 8 percent of the airport users employ the Metro, even during periods when the parking lots are full and even though more than one-half the passengers are going to or came from downtown. Chicago's O'Hare has managed to attract larger numbers of airport users to its rail system because of difficult auto access to the terminals.

6

Zurich, Switzerland is a vertically integrated airport. The top level contains the concourses where passenger loading and unloading takes place. One level below is the baggage claim area, banks and hotel reservation booths. The hotels check baggage at the booth for delivery to any hotel in Zurich and anywhere in Switzerland. A private baggage handling system delivers the baggage. The next level down provides all the transportation linkages (trains, car rentals and buses).

Rental Car - Passenger drives to Agency takes shuttle bus to terminal.

Passenger Movement in Airport

- Intraterminal transfer from carrier to carrier, gate to gate.
- Curbside to ticketing counter to gate.
- Curbside to gate.
- Interterminal transfer.
- Gate to terminal - waiting etc.
- Gate to baggage claim to curb - shuttle bus, taxi, or limousine.
- Baggage claim to parking.
- Gate to curb.
- Gate to parking.

7

AIRPORT MOBILITY

The basic design of airports depends upon reconciliation between the conflicting demands of aircraft and people. Terminal gate areas are widely spaced to minimize aircraft taxiing time, maneuver difficulty and cost. Passengers, on the other hand, require the space between terminal gates and parking, car rental, check-in, etc., to be minimized to save walking time and effort. Intraterminal transfer of up to 67% of the passengers arriving at an airport results in a severe extension of walking distances, congestion, and an overall rise in airport operating cost. Future airport design will utilize people movers to resolve the design conflicts in the most economical manner.

Westinghouse Corporation has secured most of the orders for systems, but others available, such as UTDC, Otis, TTI, Matra-VAL, M-Bahn, Bombardier, etc., all supply similar large vehicle systems with 40 to 120 passenger capacity. Policy decisions to constrain airport use to traveling passengers would reduce the capacity requirements, guideway engineering, and greatly reduce costs.

A people mover market has developed for new and expanding airports. Some characteristics include:

1) Large vehicle systems require large, heavy and costly guideways. The market for such expensive systems is limited, and invariably

requires federal subsidy because of the impracticality of charging for such short trips with no alternative provided.

2) The service characteristics of all the large vehicle systems currently are limited to line haul operation with stops at every station. Every passenger makes every stop. This limits routing flexibility and severely limits average speed.

3) Large vehicle systems which did offer a measure of route flexibility and off-line station capability such as the Boeing people mover at Morgantown and the LTV Airtrans people mover at Dallas-Fort Worth, are no longer being marketed. Their high cost was one reason for their withdrawal from the market.

4) The limited service characteristics of the current people movers are unattractive to airports for the following reasons:

a) Only passengers can be carried, but even when they arrive at the satellite terminal, they are often still faced with considerable distances (up to the FAA maximum 1,000 feet) to their gates.

b) Airlines do not want their employees to use the vehicles since many are mechanics and service people who transport tools and equipment (security?)

c) Car rental companies are not well served by a single common station in their service area. Consequently, they buy buses which are expensive to operate and get tied up in traffic, and add considerably to the vehicle traffic congestion.

d) Parking lots may be served by one or more stations with significant additional cost, but walking distances are still great for large lots.

e) Freight cannot be carried on the people mover. The loading operation would mean unacceptable dwell times. Off-line stations are required to handle freight and parcels.

f) Food service and other airline services cannot be handled because the on-line stations are not close to the aircraft gates. Handling of containers is compatible with the station design and operation.

g) Baggage cannot be handled for reasons similar to e) and f) above.

5) As a result of the limited service capabilities of the large vehicle systems, the airport design must still be arranged to allow conventional access and mobility to buses, automobiles, vans, trucks, container trains, baggage trains, etc., which means that the total construction cost savings are minimal.

Airport	People Mover	Function
Tampa, Florida	Westinghouse	Main terminal to satellite terminals shuttle. Passengers only.
Seattle-Tacoma Washington	Westinghouse	Main terminal to satellite terminals shuttle and loops. Passengers only.
Dallas-Fort Worth Texas	LTV-Airtrans	Inter-terminal group rapid transit for passengers, employees and freight.
Orlando, Florida	Westinghouse	Main terminal to satellite terminals shuttle. Passengers only.
Atlanta, Georgia Hartsfield	Westinghouse	Main terminal to satellite terminals shuttle. Passengers only.

In addition several airports have been retrofitted with people movers in order to facilitate movement between remote terminals. Some examples are as follows:

Airport	People Mover	Function
Houston, Texas	WED-Bombardier	Inter-terminal shuttle. Passengers only.
Gatwick, England	Westinghouse	Main terminal to satellite terminal shuttle. Passengers only.
Miami, Florida	Westinghouse	Main terminal to international terminal shuttle. Passengers only.

6) Transportation links to facilities outside the airport but within its vicinity, such as hotels, offices, service, repair and maintenance facilities; the large people movers cannot economically serve these facilities, since they are located over a wide area and cannot accept large stations spaced at long intervals.

7) Large vehicle people movers are usually unsuitable on account of speed, acceleration, etc., or their configuration--number of seats, vehicle capacity, etc.--or they are too expensive to deploy to a city center which may have a limited CBD to airport demand, as in Denver.

Denver Stapleton International Airport is one of the busiest airports in the nation and the world's seventh busiest. Its terminal reached its useful capacity in 1980, but a policy decision could cure that immediately. In poor weather, the proximity of existing parallel runways does not permit side-by-side landings. It is the air approach that greatly limits capacity. Increased air travel in a deregulated market has clogged operations at Stapleton where delays are second only to Chicago's O'Hare Airport. The new N-S commuter runway and E-W runway in the Arsenal will alleviate air approach limitations.

Stapleton was built to handle only passengers arriving and leaving the city when suburban sprawl was non existent. Federal deregulation of the airlines in 1978 encouraged the "hub-and-spoke" system that has

made Denver a major connecting city with a characteristic dominance of transferring passengers going from gate to gate without need for extra-terminal transportation. Contrast this fact with Orlando, serving Disney World and having minimal connecting flights. United and Continental currently operate hubs that generate about 80% of Stapleton's passenger traffic. An internal passenger/baggage/freight small vehicle people moving system is needed vice a large capacity heavy guideway system.

Table 1 shows the number of flights forecasted for Stapleton Airport (HNTB, 1985).

Table 1

Year	Average Flights/Day	Flights/Year
2000	1,723	629,000
2020	2,561	935,000

The annual average trips per flight per day for land side vehicles for commercial airports was computed using average weekday, average Saturday, and average Sunday rates (ITE Trip Generation Manual). It is 15.56. Applying this factor to the data of Table 1, the annual average daily trips (AADT) were computed and are shown in Table 2.

Table 2

Year	AADT (Vehicles/Day)	DHV (Vehicles/Hour)
2000	26,810	3,405
2020	39,849	5,061

To convert form AADT to 30th highest peak hour volume (our DHV), a factor of 12.7% was used (Highway Capacity Manual, SR 87, 1965), assuming one-directiona urban freeway conditions. This DHV is shown in Table 2.

Adequate parking is essential to the function of the airport, but can be significantly reduced by a take and drop driveup policy with suburban park-and-ride to airport bus shuttle service. The volume and characteristics of users play a major role in the planning of parking facilities. Public parking facilities are provided for airline passengers (2/15) and visitors (10/15), of current users. Adequate parking must be provided for both airport and airline employees, car rentals, limousines, buses, and taxis.

At Denver Stapleton International Airport, short-term parkers (30 minutes to 3 hours) represent only 40% of the maximum vehicle accumulation, although they account for the majority of users (75%).

The parking duration of business travelers is generally 10 hours or more. Accumulation shows no sharp peaking during the 24-hour cycle, although overnight accumulation is a little less than the daytime figure. Accumulation drops substantially on weekends and holidays. There are no sharp seasonal fluctuations. For pleasure travelers, there is a weekly cycle of peaks on weekends. There is also a seasonal cycle with peaks in the summer vacation months and during major holiday periods.

Compare this parking need to rental car movements during skiing season months.

The accumulation for short-term parking is high during the day and very low at night. There are peaks on weekends and on holidays.

There is a need for passengers to be able to check baggage inside the parking garage.

The length of the drop-off/pickup curb front can be estimated at 120 feet per million passengers (originating or arriving). Taxis, limousines, buses, kiss and ride, will have an access to the baggage check area and baggage claim area. The total required pickup and drop-off curb front requires 572 feet for taxis, 469 feet for bus transit, and 570 feet for other (shuttle buses, etc.). Bus transit to the suburban park-and-ride locations should be significantly enhanced in its ability to drop at curbside check-in stations and baggage claim doors.

It is general practice at airports to provide special parking for employees of airlines and the airport; their use patterns must be considered in the total analysis. Arrival and departure times depend upon shift changes. Parking duration is generally 8 to 12 hours. The internal people mover should provide employees transportation between parking and the terminal.

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An assessment of functional requirements shows a far different and far less expensive airport. By analyzing the actual people population of the airport, it is easy to discern some immediate and very low cost solutions to existing problems. By analyzing the functions which need to be provided (baggage, people movement, security, fueling, food servicing, air freight, etc.) some very impressive investment savings can be realized over replicating the '30s.

I have addressed only a couple by way of example.

It has been interesting to note that not one single airport study in 55 years of history has started out by determining what the functions are which need to be provided to these people who are actually air travelers. It is not too late to do the first one.

William B. Rourke

Chairman of the Board

District "N"

William Rourke, 53, left forestry studies at Colorado State University for Naval Submarine Service during the Korean War. He won a Naval R.O.T.C. scholarship from the fleet and attended the University of New Mexico, receiving the B.A. in Adult Education in 1955, and the B.S. degree in Geology in 1956. While attending college, he served as president of Sigma Alpha Epsilon fraternity and the Inter-fraternity Council. He was quite active in student government. After graduation, he married Mary Lee Quirk of San Antonio, Texas and was commissioned an officer in the United States Marine Corps.

His military career includes duties in Maintenance, Safety, and Operations, as well as Executive and Commanding Officer of transport and jet-attack squadrons. He is a veteran of four combat tours-of-duty in Viet Nam. He has been an instructor, maintenance test, standardization, and instrument check pilot. He attended the United States Postgraduate School in Monterey, California for two years, completing the M.S. Meteorology Program in 1965.

In 1974, he received his Master of Business Administration degree from Pepperdine University. During this same period of time, he was responsible for the safety program of a five-airport-complex in California and Arizona.

He is presently Professor of Aerospace Science at Metropolitan State College, a position he has held since 1976. He is also an Accident Prevention Counselor for the Federal Aviation Administration, a squadron

commander for the Civil Air Patrol, and Chairman of the Board of the Regional Transportation District.

Bill is active in a number of civic organizations within the community. He is a member of Christ The King Church of Evergreen where he is a lector. Bill is a family man with great dedication to and pride in his children. His oldest daughter, Ellen, is a graduate of the University of Colorado at Boulder. She was commissioned in the United States Navy in 1978 and has the distinction of being the fifth woman in history to be designated an aircraft carrier pilot. Bill, Jr., is a 1981 graduate of Metropolitan State College and was commissioned an officer in the Navy as well. He is presently flying antisubmarine warfare aircraft based at Barbers Point, Hawaii. Brian, the youngest, is a 1981 graduate of Evergreen High School. He is completing his senior year at the United States Air Force Academy at Colorado Springs. He intends flying F-16s.

Bill Rourke has extensive management education and experience which stand him in good stead as Chairman of the RTD. A resident of Soda Creek in the Evergreen Area, he is a frequent rider of the bus to and from his work on the Auraria campus.

Rourke served as Chairman of the Operations Committee in 1983, Chairman Pro Tem in 1984, and is currently Chairman of the Board.

Mr. GEORGE BROWN. Our next witness is Mr. Ronald L'Hommedieu, manager of construction for Dallas-Fort Worth International Airport. And he is going to tell us why that is still a perfect airport.

Mr. L'HOMMEDIEU. You have to be careful. I have to go through there about every time I go home.

Mr. GEORGE BROWN. I was through there on Friday.

Why is it that they have to do so much construction if it was so good when it was first built?

Forget that question. And we do appreciate you being here. You are one of the outstanding airports in the country. And I assume you are trying to become even better. We certainly look forward to your testimony.

Oddly enough, people like Mr. Packard and I spend as much time in the Dallas Airport as we do in almost any other airport, I am sure.

Can you see if you can keep your comments under 20 minutes? Leave a little time for questions?

STATEMENT OF RONALD L'HOMMEDIEU, MANAGER OF CONSTRUCTION, DALLAS-FORT WORTH INTERNATIONAL AIRPORT

Mr. L'HOMMEDIEU. Mr. Chairman, committee members, while the purpose of this hearing is to hear testimony on the state-of-the-art technology which can affect the Denver Airport, and the area of construction, it may be well to more fully utilize existing technology than to search for new and untried technology. Opportunities exist in many construction related areas to do things better, including terminal planning and layout, material selection and utilization, and project construction management.

It has been said in the design and construction business that the same mistakes are repeated over and over. If this is as true as experience may indicate, this repetition is certainly the least excusable of our mistakes. The new Denver Airport project provides Denver and those involved the opportunity to break this change of repetition and contribute significantly to the new airport.

This hearing demonstrates an awareness of that opportunity and the commitment of our Government and its agencies to channel funds and human resources into improving traditional approaches to the implementation of this project.

It must be anticipated that terminal interior layouts will be frequently and extensively reconfigured during the course of their usable life. The ability of the basic concept to meet these future and unknown demands will affect the economic effectiveness of the terminal concepts and may well control the determination of the usable life of this airport.

Airline equipment requirements and the ever-changing marketing approaches of the airlines will dictate changes which cannot be anticipated by planners and designers except in a conceptual context. Public and passenger circulation areas of the terminal can be anticipated and provided for in the initial stages, but the requirements of leased areas occupied by concessionaires and airline tenants must be provided for through extremely flexible space planning and mechanical and electrical services. To some limited

extent, these lease spaces can be likened to commercial space in a mall or office building, where tenants and tenant needs change regularly, and renovations are carried out for each new tenant within the given shell of the building. In order to provide this flexibility, at least three major concerns should be addressed during concept development and design.

The building must provide maximum economical column spacing and adequate floor to underside of structure distance. Maximum economic column spacing will provide the flexibility to change floor plans as needs change, and will be limited by structural economies and the desirability to provide modular design which recognizes the spacial requirements of present and foreseen airline equipment.

The floor to underside of structure dimension will control much of the facility's flexibility, should provide freedom and modifying architectural layouts and mechanical and electrical systems to meet future requirements.

In architecture, it is basic that required space be defined, and the building frame and envelope be designed to contain that space in the most economical manner consistent with the design intent. An airport design, a design of the envelope is repeatedly shortsighted. The space is pared down to the minimum spacial requirements of the initial functions and systems envisioned at the time the concept is finalized. It has been proven repeatedly that this is false economy and later costs of renovation outstrip the well intended, initial economies. This paring down, which is ingrained in all good designers, must be anticipated and controlled.

Mechanical systems, in particular the air distribution systems, should be modularized to the greatest extent possible, so that the flexibility to service future layouts with the same quality of service which is provided to the original layout is available. This modularization will affect secondary and tertiary air distribution duct work design and control systems. The secondary air distribution duct work design should provide the flexibility to make local changes in the tertiary distribution system without impact on the efficiency of the overall system, or significant cost penalties for modifications of the system.

Changes to the electrical system will be required in almost all instances where use and layout are revised. Electrical power distribution systems can effectively and economically provide higher voltage electrical power more generally throughout a facility such as terminal buildings. The cost of higher capacity distribution systems installed initially can be offset by reduced energy costs due to savings and distribution losses and lesser cost of system modification during future renovation. Added distribution panels and metering points will provide the flexibility to meet future needs economically. Further, consideration should be given to relocating electrical and communications closets away from terminal passenger levels, to further expand the flexibility of utilizing floor space and subsequent changes in use and layout.

Materials and equipment are being developed or adapted for construction use, utilizing new technology and design concepts at a rate that precludes acceptance testing that truly provides the confidence that is commensurate with decisions to incorporate these materials into heavily used facilities, utilizing public money for rel-

atively long life is a requirement. Examples of premature obsolescence surround us as a result of unproven design concepts or material and equipment misapplication.

In design areas, where strength and capacity are key factors in design, computers which provide multidecimal point accuracy are being used without question to refine design applications of materials whose physical properties cannot be controlled in the field within plus or minus 10 percent.

Without blindly turning our heads to the potential of technological advances which are available to designers, a rational approach to selection and application of these new materials and equipment is mandatory to protect the long-term investment of facilities such as the new Denver Airport. A form of risk management might be successfully applied to these selections in addition to the architectural and engineering studies which are expected from professional designers. Areas of high risk might include foundations, structure, and building envelope where dependability is crucial. In these high risk areas, techniques and materials should be selected through a conservative decision process which ensures highest possibility of success. This conservative approach may entail selection of traditional materials with proven results or consideration of new materials where indepth testing during selection is carried out and stringent quality control is exercised during construction.

There is great merit in conservatism, over-design, if you prefer, to provide a durable and reliable space in which this business of running an airport can be conducted. The stakes in the multibillion project will not provide technical and aesthetic experimentation without the tightest risk management control. On the other hand, a blindly conservative approach to design cannot be permitted to rule out the exploration of new technology which holds the promise of improvements in quality, costs, and schedule.

Today, the areas of architectural finishes and energy system management probably affords more reliable new technology to the construction industry than any others. In these areas, our industry is able to benefit from billions of dollars of research and development of the space and electronics fields, and directly adapt new technology to applications which require minimal validation for acceptance and reliability.

In the area of project or construction management, there may exist more unused or poorly used management technology than most other fields. The construction industry, including architecture and engineering, has traditionally been dominated by individuals with innate management capabilities which have transcended formal management educations and training. The very nature of this high risk business has distilled the risk takers into an elite group of self-made businessmen. The industry is emerging from that area, but tradition dies hard and the reliance on intuition over the elements of management principles is still very much in evidence.

There are literally hundreds of management control systems available to the industry today which provide essentially the same controls for schedule, resource management, and administrative matters, and are distinguished chiefly by the experience and preferences of the developer of the system. Without extreme over-sim-

plification, the selection of a computerized management control system could almost be based on the relationship of the size of the project and the data capacity of the available systems. However, two very real pitfalls do exist in the successful use of these systems: the failure to truly implement the system and exploit the capabilities available; and the temptation to change or upgrade systems to realize the benefits of the system rather than exploit the existing system.

For a project of the size and complexity of a major new airport, the project management system is a necessity to ensure attention and documentation of all areas of control required. Project management concepts cannot be initiated too early in any major undertaking. While early emphasis is traditionally centered on master planning, a plan for the actual implementation of the project will serve as the most effective control tool to assure that all necessary activities are carried out on schedule. This implementation plan providing a yardstick for the project management system will form the backbone of the detailed plan and schedule for the execution of the project.

In today's governmental system of agencies exercising various controls over a major airport project, a key element in the implementation plan will be a sociopolitical engineering, the process of studies, approvals, grant processing, and public information that is often a key to successful implementation as much as the technical aspects of major projects.

Today's construction marketplace is evolving in many ways as a response to client, A/E, contractor, and labor experiences since the 1950's. With a single, multibillion project at stake, major consideration should be given at the outset to the overall contracting philosophy, preparation of contract tailored exclusively to the needs of this project, and provision of insurance including such specialized coverages as professional liability insurance.

A contracting philosophy of a project of the magnitude and duration of the new Denver Airport should recognize the current atmosphere in the construction industry and the geographical region of the airport, and provide the flexibility to anticipate and respond to the changes that will take place in the economy over the next 10 years, as it affects contracting for the airport. The affects of this project on Denver, the Front Range, and indeed the western two-thirds of the United States is going to be significant. Its impacts on the construction market will be significant and worthy of careful and continuous evaluation to benefit all of those touched by these influences.

It goes without saying that the cost of insurance for this project will be enormous. The trends toward wrap-up coverages for major projects must be considered. However, it is not inconceivable that insurance will not be available. By default, self-insurance is becoming more feasible in projects of the nature of the new Denver Airport project.

In summary, the quest for and utilization of latest technology is important to the airport. New developments must be identified and applied to propel this project into the 21st century with the momentum to sustain its usefulness throughout its economic lifetime. It may be that one of the most significant contributions which can

be made to this success is an early effort to better apply existing methods and planning and management.

Thank you.

Mr. GEORGE BROWN. Thank you very much, Mr. L'Hommedieu.

You are making some changes in the Dallas-Fort Worth Airport, I guess. Is that a reflection of the first point that you made about the design of the envelope is repeatedly short-sightedness? Or what is the reason for that?

Mr. L'HOMMEDIEU. The changes come about primarily because of the shifting airline needs. Certainly, the increase in traffic has affected that. The difficulty of implementing those changes is a product of the lack of early planning.

Mr. GEORGE BROWN. I would gather that even if we did a perfect job of designing the Denver Airport that even if airlines major shifts in their utilization or operations, we would still have to make changes.

Mr. L'HOMMEDIEU. Yes, sir. The difference in the processing of passengers, even their marketing concepts are going to affect that. And those change literally daily.

Mr. GEORGE BROWN. Of course, that emphasizes the importance of the point that you made about developing modular designs which can be changed with minimum expense when it is required to make those kind of adaptations.

Mr. Packard, do you have some questions?

Mr. PACKARD. I am still not clear on one fundamental question that I think Mr. L'Hommedieu could answer. And that is, what major changes would you make from what you have done at Dallas-Fort Worth if you were designing and building a new airport? What have you learned from Dallas-Fort Worth?

Mr. L'HOMMEDIEU. I am relatively new at Dallas, so I do not have all of the background. I think a portion of the points that Mr. Rourke made would be important; the air-trans system, or the people-mover system is in the process of major reconsideration. The concept of the airport in general is a very good one. It has been impacted by the deregulation, the hubbing, and also the fact that Braniff went out of business shortly after that airport was really established. And what it has done is unbalance the two sides of the airport.

Those kinds of things you cannot really anticipate, but certainly you need the flexibility to react to those changes.

Mr. PACKARD. I do not have any further questions, Mr. Chairman.

Mr. GEORGE BROWN. Hank.

Mr. HANK BROWN. Thank you, Mr. Chairman.

You have already discussed building design and developing a modular technique that is flexible. What do you see as other things that the airport can focus on to provide for that flexibility for unknown changes in technology?

Mr. L'HOMMEDIEU. Well, the primary thing is enough space and, really, just a basic sound structure that will allow you to do anything within that space that you can reasonably conceive of. There are areas—we touched on baggage handling. We are using technology in baggage handling that is probably 30 or 40 years old. In the 1970's, there was a development of computerized baggage systems

that had a lot of flaws in them, and those systems have primarily been discarded because of the problems and unwillingness of ironing out those problems.

I think that the potential to use those systems to provide us a flexibility to take care of changes are really important to us and should be explored.

Mr. HANK BROWN. With regard to space, I assume you are talking about not just building space, but land space, raw land space. And I appreciate that there is a difference in aircraft requirements and landing space requirements between a level close to sea level, where——

Mr. L'HOMMEDIEU. Yes.

Mr. HANK BROWN. We have talked in terms of from 20 square miles up, perhaps as high as 40 to 60 square miles. Do you have a figure in your mind that would provide ample space for future planning? What would be the ideal space that you think we ought to be thinking about?

Mr. L'HOMMEDIEU. Well, there is not an answer to that because—for two reasons. One, Stapleton was built some 40 years ago, and no one anticipated at that time that we would be so crowded as we are today. Los Angeles, Seattle, Houston, Dallas, every major airport has been land-locked. If we provide 60 acres or 60 square miles in Denver, in another 40 years I suspect we are going to sit around and say, "I wonder how those people developed this airport and did not anticipate the growth that we have had?"

The saving grace in what is available today, I believe, is the new technology in aircraft and possibly the operations of the airlines that will affect us in space utilization in another 10 or 15 years.

Mr. HANK BROWN. Space-wise, what is Dallas-Fort Worth?

Mr. L'HOMMEDIEU. It is 17,000 acres, approximately 30 square miles.

Mr. HANK BROWN. One last question, if I may. You mentioned potential insurance costs, and so on. Are there any specific changes in liability statues, either at the State or Federal level that would be particularly helpful in dealing with that?

Mr. L'HOMMEDIEU. Probably something like high risk automobile insurance. We are in a position today where virtually it is impossible for a professional designer to buy insurance to cover his professional liability. Traditionally, we have been asking each to provide his own insurance. And what is happening is that we, the client, are paying that premium two, three, or four times. We are getting into situations over and over again where, for a small project, the premium for insurance may well exceed the cost of the actual work. So some legislation to require coverage and probably downstream some controls on the recovery of damages in claims is going to be important to us.

Mr. HANK BROWN. Thank you.

Mr. GEORGE BROWN. Mr. Brown raised a very significant question to more than just the construction field, the impact of high liability damage—claims on aircraft owners and manufacturers and various others. It has gotten really out of hand, according to hearings that we have had in Washington. And it indicates, probably, a thorough overhaul of the whole system.

Thank you very much, Mr. L'Hommedieu.

Our last witness this afternoon is Mr. Leo Duggan, vice president of technical affairs, Airport Operators Council International.

Mr. Duggan, we are doing very well on the schedule here. We may be able to wind up by 3.

Mr. DUGGAN. I can do it in 10 minutes, Mr. Chairman.

Mr. GEORGE BROWN. If you have to leave out something, we will call you back in Washington, and you can come in and finish it up.

You may proceed. The full text of your statement will appear in the record.

STATEMENT OF LEO DUGGAN, VICE PRESIDENT, TECHNICAL AFFAIRS, AIRPORT OPERATORS COUNCIL INTERNATIONAL, WASHINGTON, DC

Mr. DUGGAN. Mr. Chairman, on behalf of our U.S. members, we are pleased to have the opportunity to express our views on issues that affect the capacity of our Nation's air transportation system.

It is fitting that the committee chose to hold these hearings in Denver, where plans are ongoing for the construction of a completely new airport over the next 8 to 10 years. This is a huge community commitment in that a project of this size takes years to plan and construct and engages thousands acres of valuable land, and may cost as much as $1½ billion.

Interestingly enough, in the last 15 years, there have been very few air carrier airports constructed and perhaps fewer than 15 air carrier runways constructed in this country. Yet in 1985, passenger enplanements exceeded 1 million per day for the first time, and at the end of the decade the air carrier enplanements will approximate 645 million. Counting regionals and commuters, that total will approximate 700 million by 1997 or the year 2000.

This lack of airport capacity seriously threatens the viability of the air transportation system; the issue is critical, and Congress needs to address it now.

Mr. Chairman, the AOCI has been chairing the industry task force on capacity improvement and delay reduction since its outset in 1982. We have mentioned in our testimony here five items that are of interest to us because they do enhance airport capacity. But Mr. Blake touched upon them in his testimony earlier today, and, therefore, I will skip on.

Of key interest to us is the need for pavement research and development. The industry task force, in making its initial report to the FAA, expressly voiced its concern that although more than 60 percent of the Federal grant in aid funds have been expended for airport pavement construction, rehabilitation, and associated activities, historically, little effort has been expended to provide research support in this area. This lack of commitment on the part of the FAA in providing adequate funding and right to precedence over other R&D items has relegated the airport pavement designer to depend upon research activities in the field of highway design, although it has been known for years that highway and airport pavement problems are radically different. In our view, this is not a cost effective route to determining why airport pavements fail.

Assuming the airport improvement program will provide Federal grants to airports at a level of about $1 billion, approximately $600

million is devoted to pavement rehabilitation and construction. When one considers the expenditure of municipal and State funds, including maintenance, approximately $2 billion per year is spent on pavements. Over the next 15 years, the amount spent for pavements could rise to $3 billion because of the increased use of high performance aircraft at congested airports.

The airport pavement design procedures currently used are about 40 years old and evolve from highway design. However, the design of airport pavements is substantially different from that of highways. Aircraft have much heavier loads, upward of 400 tons must be supported, and each pavement must be designed to meet local conditions and requirements. Loadings on highway pavements are controlled through actual weight constrictions; thus, highway pavements are not subject to the widely variable loading experienced at airports.

It is time to return to the basics of airport pavement design. Today, the wide availability of computers makes the use of sophisticated design and analysis possible. Current design procedures are extremely cumbersome for developing alternative pavement design. A universal design procedure is needed whereby different pavement alternatives can be quickly evaluated to provide for the development of new techniques to prolong their useful life, minimize their availability, and reduce investment and life cycle costs.

Mr. Chairman, on the item of contaminated runways, there is a lot of work to be done in that area. The FAA does have a program ongoing. It has been ongoing for 3 years. We have been participating in it. It has not been too successful at this point because it is a data-gathering exercise and we have not had any snow on the east coast.

However, we would recommend that the FAA undertake the following: A program for predicting aircraft stopping capability under various runway surface conditions; additional work on new pavement design and construction to maximize surface traction, and this should include, for example, detailed tests and analysis on such items as porous friction courses, reflex percussive grooving, and other possible cost-effective surface finishes.

The next three items, Mr. Chairman, deal with lighting. Our airport lighting systems are getting old, and we need work to be done in the instance of research into increased efficiency and increased reliability to include lighting system control. The computer capability out there now is great, and we should be looking into such issues as reliability and redundancy, and the FAA should be researching this and developing specifications that would make the system even better.

An issue of concern is runway incursions. Each year a number of runway incursions occur within the airport system. Usually they occur because of some inadvertent act of a controller or a pilot. It is a complex issue and solutions to the problem have been discussed within the International Civil Aviation Organization, the FAA, and other State civil aviation administrations for years. There is no agreed position on how to solve this problem. Research in this area should be intensified to identify the best means of assuring that pilots do not enter an active runway by mistake.

Wildlife control. It was interesting that in my trip out here this morning, Mr. Chairman, to note that there was an item on the Washington, DC, FAA-operated airports, Dulles and Washington National; and Jim Wilding, the administrator of the airports, mentioned that his greatest problem at Dulles International is wildlife control.

Over the years, we have attempted to approach this problem through habitat modification, denying wildlife either food, water, or shelter, or roosting accommodations. Active control involves use of noise devices to disperse birds, fencing for deer control, shotgun patrols to disperse birds, trapping and relocation or lethal control. Airport operators have found, however, that the use of active control devices have limited affect on bird dispersal. New emphasis should be placed on research to find why birds and other wildlife are attracted to airports.

Mr. Chairman, firefighting and rescue is very expensive for airports. It is particularly onerous to the small airport. And, unfortunately, firefighting and rescue service on a national scope represents a very limited market. Consequently, there is limited movement by manufacturers to make their product more cost-effective. Essentially, the airport operator has no way of demanding that the product be improved. In light of these circumstances, we believe it is incumbent on the FAA to lead the R&D effort in this area.

Wake vortex is probably the single most significant contributor to airport capacity reduction. The FAA and NASA have been exploring this issue for some 15 years with no positive results. Although the FAA is testing a wake vortex advisory system, the program appears to have limitations. There is need for an R&D program that will develop a capability to assess the energy or the energy decay in a vortex in real time to permit the wake vortex management to allow 100 percent utilization of aircraft dynamic spacing capability. For this to be achieved in the near term, will require a vigorous R&D effort.

I was pleased to note this morning that Dr. Colladay, from NASA, mentioned the tilt rotor aircraft. We believe the tilt rotor aircraft technology has progressed to the point where it appears the military services are near authorizing full-scale development. This technology could provide a totally new short-haul transportation system operating from city center to city center. The diversion of much of the short-haul market from the major airports to new facilities in the urban sector could provide a substantial increase in the Nation's air transportation system. The 1-hour range of the tilt rotor was estimated to be 350 miles, and the 2-hour range, 700 miles. The number of passengers flying the 2-hour range of this aircraft from the Nation's major hubs numbers in the millions. The aircraft is quiet; it would create no noise problems outside the small shuttle port it would require. We urge the FAA and the industry to pursue and exploit this technology.

Mr. Chairman, airport operators are not usually metereologists, but we are very concerned about the wind shear problem. And we encourage further research, and we applaud the efforts of the FAA and the industry to effectively deal with the problem; and we would encourage continued intensive research to end this threat both to the airport capacity and to air safety.

Environmental issues are always a concern to the airport operator. AOCI estimates that between 7 and 9 million airport neighbors are impacted by aircraft noise. Aircraft noise constitutes the primary constraint upon the development of the aviation system. The extreme difficulty encountered in obtaining public approval for the construction of new airports, for the expansion of existing airports, and for the scheduling of aircraft operations at night is largely the result of community opposition to aircraft noise. Noise annoyance is a national problem affecting the total air transportation system.

We are pleased that stage 1 aircraft are either grounded or effectively treated through hush kits. We are concerned that stage 2 aircraft are still being produced, and that there are no outer limits in the cessation of operations of these aircraft. AOCI has long supported corrective amendments to FAR part 36, that would prohibit U.S. airframe manufacturers from producing stage 2 technology aircraft for sale within the United States beyond January 1, 1986, which of course has just passed.

AOCI urges the immediate establishment of a Federal regulatory program to phase out operations of stage 2 aircraft into U.S. airports with a target of cessation of their operations by January 1, 1995.

And, finally, we urge continuing study of more stringent FAR part 36 standards to include standards for stage 4 aircraft.

Very quickly, we have a very urgent need for aircraft—airport surface detection equipment. We have the capability to autoland aircraft right now in category III zero-zero conditions. We have no capability to get the aircraft from the runway to the gate. And we urge research in this area.

In conclusion, we cannot overemphasize the importance of airport research and development, particularly as it relates to safety, airport capacity improvement, and to the vitality of the Nation's air transportation systems. As noted earlier in this report, airport R&D has been severely underfunded in the past, in part, perhaps because past budgets have submerged these funds in a much broader category; and as a result of low priorities, necessary airport research has been neglected. It is important that the FAA Administrator take action that will ensure that a separate line item will be included in future FAA budget submissions for the specific support of airport research activities. Over the past years, airport research, when it comes into competition with black boxes, has always fared very badly.

Mr. Chairman, on April 22, 1982, Don Reilly, executive director of AOCI, in his capacity as chairman of the industry task force on airport capacity improvement and delay reduction, briefed this subcommittee on the fiscal year 1987 FAA research, engineering, and development budget request.

We are pleased to note that the report of the House Appropriations Committee, on July 17, 1986, announced that the committee recommends an increase of $5.5 million over the budget request for airport capacity research. We find this support very encouraging, and we ask for the continued support of this committee so that we can have a stabilized airport capacity R&D Program.

Mr. Chairman, that concludes my remarks.

Mr. GEORGE BROWN. You have done very well, Mr. Duggan, and we appreciate that. You have, of course, spoken to the issue that is of primary issue to this subcommittee, namely, the adequacy of research and development funding. I did not—you listed a lot of areas that require further research and development, but then you added a couple of paragraphs to your statement, indicating that you felt we needed to increase the amount of funds in the current budget for that purpose. That was the first question I was going to ask you, and you have already answered it. And we appreciate that very much.

We are still concerned that the increase that you referred to may not be adequate to handle the problems in the timeframe that we need. And we will want to get further opinions from you and others on that question.

Mr. DUGGAN. We would be happy to answer.

Mr. GEORGE BROWN. Mr. Packard, do you have any questions?

Mr. PACKARD. Just as a followup, it was obvious that you have recommended a great deal of continued research in several areas.

Do you feel that we are utilizing the existing technology to the extent that we are capable of doing?

Mr. DUGGAN. Well, I think the work of the industry task force has done quite well. Of course, what we must recognize is that there is no dramatic way of increasing airport capacity unless you go out and build new airports. But the steps we are taking, that the task force is taking, and as Mr. Blake mentioned today, these are incremental increases. They are producing significant gains, but the possibility exists that we are only keeping up with the growth. I don't know that we are gaining.

Mr. PACKARD. Thank you, Mr. Chairman.

Mr. GEORGE BROWN. Hank.

Mr. HANK BROWN. No questions. Thank you.

Mr. GEORGE BROWN. Mr. Duggan, the hour of 3 has arrived. You have done very well in helping us. We appreciate you coming out for this, and we will keep in close touch with you.

The subcommittee will be adjourned at this time. We thank all of the participants who gave so generously of their time.

[Whereupon, at 3 p.m., the subcommittee adjourned.]

[The prepared statement of Mr. Duggan follows:]

AIRPORT OPERATORS COUNCIL INTERNATIONAL

TESTIMONY

of

AIRPORT OPERATORS COUNCIL INTERNATIONAL

on

AIRPORT TECHNOLOGY AND RESEARCH NEEDS

Before the Subcommittee on Transportation,
Aviation and Materials

Committee on Science and Technology

U.S. House of Representatives

Washington, D.C.

July 28, 1986

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Mr. Chairman and Members of the Subcommittee, I am Leo F. Duggan, Vice President of Technical Affairs, for the Airport Operators Council International (AOCI). AOCI is an association of governmental bodies that own and operate the principal airports served by scheduled air carriers in the United States, as well as in many countries abroad. Our U.S. member airports annually enplane more than 90% of the domestic and virtually all of the U.S. international scheduled air carrier passenger and cargo traffic. In addition, our local governmen members operate many reliever and other general aviation facilities which supplement the larger airports in their communities and regions.

On behalf of our U.S. members we are pleased to have the opportunity to express our views on issues that affect the capacity of the nation's air transportation system. It is fitting that the committee chose to hold these hearings in Denver where plans are on-going for the construction of a completely new airport over the next eight to ten years. This is a huge community commitment in that a project of this size takes years to plan and construct, engages thousands of acres of valuable land and may cost as much as one and a half billion dollars. Interestingly enough in the last 15 years there have been very few air carrier airports constructed and perhaps fewer than 15 air carrier runways. Yet in 1985, passenger enplanements exceeded one million per day and at the end of the decade air carrier enplanements will approximate 645 million. Adding the enplanements of the commuters and regionals at 55 million and the industry is facing the task of enplaning approximately 700 million passengers in our current airport system.

This lack of airport capacity seriously threatens the viability of the air transportation system. The issue is critical and Congress must address it now.

The FAA sponsored Industry Task Force on Airport Capacity Improvement and Delay Reduction has been in being since 1982. This independent task force was created to evaluate the immediate and near term needs to increase capacity at airports and report those recommendations to the FAA for its evaluation. Upon the request of the FAA, AOCI agreed to chair this task force which has in its membership representation of all segments of the aviation industry. The task force, in its initial report, identified and unanimously recommended some 90 separate initiatives to increase airport capacity. None of the identified initiatives can, on its own merit, create huge capacity gains, however, incremental increases are significant. A number of these proposals merit a brief discussion.

1. Reduced Aircraft Longitudinal Separation

To safely reduce spacing between aircraft in-trial from the current 3 to 5 NM to 2 to 2 1/2 NM while approaching to land. Dependent on airport flow and configuation this can add one to six flights per hour.

2. Reduced Parallel Runway Spacing

The objective is to reduce the spacing between independent IFR parallel runways from the current 4,300 feet down to as low as 3,000 feet. Expedited development and analysis of ground-based sensors is necessary to show this to be a safe operation. Expedited development

will also allow airport planners to adopt the new design and construct closely spaced runways on existing and future airports.

3. IFR Converging Runway Operations

The FAA recently approved this concept at specified airports; however, it is considered only a first step and further concepts are possible. It is necessary to establish requirements and validation methods for lower minimum IFR converging runway operations.

4. Short Runways and Triple Parallels

Triple IFR parallel approaches and simultaneous use of short runways appear feasible with the present ATC system and equipment. It is hoped that the sensors selected for use in conjunction with closely spaced parallel runways will be able to perform this task too.

5. Visual Segment Approaches

This concept is in operation at St. Louis (side step) and Denver (offset). This allows offsetting the final fix localizer to provide the required separation for independent parallel IFR operations. When the pilot visually recognizes the runway he "dog legs" to get in position for landing. The concept has produced a capacity increase of 18 operations per hour under certain conditions. This is very significant.

The items briefly described above are task force initiatives that essentially deal with air traffic control and black box technology. AOCI supports these initiatives because they enhance airport and

system capacity. I would like now to express our view on airport related research and development needs.

Airport Related R&D

Pavement R&D

The Industry Task Force in making its initial report to the FAA expressly voiced its concern that although more than 60% of the Federal Grant-in Aid Funds have been expended for airport pavement construction, rehabilitation and associated activities, historically, little effort has been expended to provide research support in this area. This lack of commitment on the part of the FAA in providing adequate funding and right to precedence over other R&D items has relegated the airport pavement designer to depend upon research activities in the fields of highway design, although it has been known for years that highway and airport pavement problems are radically different. In our view, this is not a cost-effective route to determining why airport pavements fail.

Assuming the Airport Improvement Program (Trust Fund) will provide Federal grants to airports at a level of about $1 billion per year, approximately $600 million is devoted to pavement rehabilitation and construction. When one considers the expenditure of municipal and state funds, including maintenance, approximately $2 billion per year is spent on pavements. Over the next 15 years, the amount spent for pavements could rise to $3 billion because of increased use of higher performance aircraft at congested airports.

There are about 650 million square yards of pavement at our nation's airports. Replacement value is estimated at $100 billion; however, practical possibilities for adding to or replacing major

pavement systems are limited. Consequently, maximum benefits must be obtained from the existing facilities. This requires maintaining and improving the existing facilities and fully supporting research to reduce or resolve problems contributing to construction-related delays at congested airports. Furthermore, operational limitations must be assessed and pavement management procedures must be undertaken to assure proper maintenance, to minimize interruption of service, and to maximize investment without compromise to safety.

The airport pavement design procedures currently used are about 40 years old and evolved from highway design. However, the design of airport pavements is substantially different from that of highways. Aircraft have much heavier loads, upwards of 400 tons must be supported, and each pavement should be designed to meet local conditions and requirements. Loadings on highway pavements are controlled through axle weight restrictions, thus highway pavements are not subject to the widely variable loading experience at airports.

It is time to return to the basics of airport pavement design. Today, the wide availability of computers makes the use of sophisticated design and analysis possible. Current design procedures are extremely cumbersome for developing alternative pavement design. A universal design procedure is needed whereby different pavement alternatives can be quickly evaluated to provide for the development of new techniques to prolong their useful life, maximize their availability and reduce investment and life-cycle costs.

Contaminated Runways

For over a decade, the FAA and later NASA have been investigating the merits of friction measuring vehicles. The results to date have not been conclusive. There has been similar activity overseas. In 1982, FAA embarked on a program of evaluating various friction measuring devices to develop a data base on "contaminated (snow, ice, sleet, freezing rain) runways."

Airport operators have not yet been greatly aided by friction measuring device technology (Mu-meter, Skiddometer, Saab and Diagonal Braking Vehicles are examples) to determine whether snow or ice-covered runways will provide adequate braking action during landings. Few if any airports use just these devices for determining runway conditions during snow or icing conditions. In our view, such friction measurement information only supplements data gathered from other sources, such as the Snow Removal Committee, an experienced operations supervisor or field maintenance personnel. These personnel may buttress their conclusions by the use of a small truck or station wagon to further determine the friction qualities of the runway. This is the time honored way of determining the runway condition, and such data does indeed aid in the total determination by reporting the actual physical condition of the runway as often as the condition changes.

Having said this, AOCI supports the friction measurement research program the FAA embarked upon in the 1982-1983 winter season, and is actively participating in the program. We encourage FAA R&D activity that will permit airport management to provide more accurate information to controllers and to pilots. That is our job --

condition reporting and maintaining these surfaces in usable condition.

AOCI believes that additional work in the area of airport surface conditions has the potential to improve airport capacity while enhancing flight safety. With confident knowledge as to the state of actual surface conditions, pilots could optimize their landing and takeoff techniques and substantially modify their runway occupancy times, especially during periods of inclement weather.

Because of this potential significant payoff, additional FAA R&D work should be continuing and broad enough to cover the entire spectrum of: new pavement design and construction to maximize surface friction characteristics; maintenance methods and materials to retain a high level of surface traction; and friction measurement techniques together with improvements in the dissemination of surface condition information to controllers and pilots.

We recommend that FAA undertake the following: a program for predicting aircraft stopping capability under various runway surface conditions; and additional work on new pavement design and construction to maximize surface traction. This should include, for example, detailed test and analysis on such items as porous friction courses, reflex percussive grooving, and other possible cost-effective surface finishes.

Visual Guidance System

It was noted earlier that there will be a dramatic increase in enplanements and aircraft operations at airports by the end of the decade. As the proportion of this activity that is performed by aircraft certified for Category III opeartions increase, traffic

density during periods of very low visibility will increase. Hence, severe demands will also be placed upon visual guidance systems used for guiding and controlling aircraft between the runway and the apron parking or passenger loading positions.

Many lighting systems at our airports have been in for many years and are approaching the end of their useful lives. Light systems may be upgraded along with a project to add to the airport capacity, or to attain lower operating minimums. When the equipment is upgraded, the principal considerations of the airport operator are to minimize energy consumption and maximize reliability. Failure of the entire system may result in the temporary loss of operating minimums and the failure of individual fixtures results in runway downtime for maintenance. These consequences of lighting failure reduce airport capacity and are therefore highly undesirable.

Taxiway Lighting System

High-speed exits were designed to reduce runway occupancy time. High-speed exits have never been properly utilized and this can have a direct bearing on increased airport capacity.

At airports with high-speed exits, a path of green centerline lights may be used to lead the pilot off the runway at a high rate of speed. These lights work well under good-visibility conditions but with reduced visibility they appear too quickly for the pilot to adjust the breaking for a smooth turn off. These exits and lighting systems should be investigated and improved in the interest of safety and airport capacity.

Lighting System Control

The control of airport lighting systems is undergoing radical change. The existing system is archaic and requires a separate wire for each possible signal when the controller in the tower throws a switch to select a particular lighting function. While the system is relatively simple, it requires a large number of lines and relays which are expensive to install or replace.

As the airport runway and taxiway layout becomes increasingly complex, the controller spends more time switching on the various systems and regulating their intensity. An automated control and display system reduces the controller's work load and permits him to monitor the system at a glance. Monitoring the system to ensure adequate lights are functioning is very important when operating in CAT II and CAT III conditions.

A number of larger airports have elected to replace their lighting control systems with a computerized system. Since there are no universal specifications for the new systems each airport is in a sense developing his own control system. Issues such as reliability and redundancy need to be addressed. FAA should research these systems and provide guidance to provide minimum standards for safety and reliability.

Runway Holdline Markings and Lighting

Each year a number of runway incursions occur within the airport system. Usually they occur because of some inadvertent act on the part of a controller or a pilot. It is a complex issue and solutions to the problem have been discussed with the International Civil Aviation Organization (ICAO), the FAA and other State civil aviation

administrations for many years. There is no agreed position on how to solve the problem. Research in this area should be intensified to identify the best means of ensuring that pilots do not enter an active runway by mistake.

Wildlife Hazard Control

Each year approximately $40 million damage is done to aircraft through encounters with wildlife, largely engine ingestion of birds. Most airport wildlike control methods come from research on wildlife control for agricultural crop protection. This has led to two possible control methods: habitat modification and active bird control. Habitat modification involves denying wildlife either food, water or shelter, or roosting accommodations. Active control involves use of ;noise devices to disperse birds, fencing for deer control, shotgun patrols to disperse birds, trapping and relocation or lethal control. Airport operators have found that the use of active control devices have a limited effect on bird dispersal. New emphasis should be placed on research to find why birds and other wildlife are attracted to airports.

Firefighting and Rescue Service

The provision of crash/fire/rescue services at airports is very costly. It is particularly an economic burden at the small airport. Some years ago FAA sponsored a study to determine whether CFR services were economically justifiable at airports. The study concluded that such services were not economically justifiable at small airports. Largely, aircraft accidents do not occur at small airports. Although we know of no airport authority who has

discontinued CFR services on the basis of that study we know many airport authorities who would welcome some relief from the costly burden.

Unfortunately, the firefighting and rescue service on a national scope represents a limited market. Consequently, there is limited movement by manufacturers to make their product more cost-effective. Essentially, the airport operator has no way of demanding that the product be improved. In the light of these circumstances, we believe it incumbent in the FAA to lead the R&D effort in this area.

Wake Vortex

Wake vortex is probably the single most significant contributor to airport capacity reduction. The FAA and NASA have been exploring the issue for some 15 years with no positive results. Although FAA is testing a Wake Vortex Advisory System the program appears to have limitations. There is need for an R&D program that will develop a capability to assess the energy or the energy decay in a vortex in real time to permit wake vortex management to allow 100% utilization of aircraft spacing capability. For this to be achieved in the near term will require a vigorous R&D effort.

Tilt-Rotor Aircraft

The Tilt-Rotor aircraft technology has progressed to a point where it appears the military services are near authorizing full-scale development. This technology could provide a totally new short-haul transportation system operating from city center to city center. The diversion of much of the short-haul market from the major airports to new facilities in the urban sector could provide a

substantial increase in the nation's air transportation system. The one-hour range of the Tilt-Rotor is estimated to be 350 miles and the two hour range at 700 miles. The number of passengers flying in the two-hour range of this aircraft from the nation's major hubs number in the millions. The aircraft is quiet and would create no noise problems outside the small "shuttle port" it would require. We urge the FAA and the industry to pursue and exploit this technology.

Weather Considerations

The phenomena of the "wind shear" has long been of concern to air crews and the aviation community. Since the mid-1970s when wind shear first became recognized as a serious factor in major aircraft accidents, attempts have been made to develop equipment and techniques for predicting and coping with wind shear conditions. Airport operators applaud the efforts of the FAA and the industry to effectively deal with this problem. We encourage continued intensive research to end this threat to both airport capacity and air safety.

Environmental Factors

AOCI estimates that between seven and nine million airport neighbors are impacted by airport noise. Aircraft noise constitutes the primary constraint upon the development of the aviation system. The extreme difficulty encountered in obtaining public approval for the construction of new airports, for the expansion of existing airports and for the scheduling of aircraft operations at night is largely the result of community opposition to aircraft noise. Noise annoyance is a national problem affecting the total air transportation system.

We are pleased that Stage I aircraft are either grounded or effectively treated through hush kits. We are concerned that Stage II aircraft are still being produced and that there is no outer limit in the cessation of operations of these aircraft. AOCI has long supported corrective amendments to FAR Part 36 that would prohibit U.S. airframe manufacturers from producing Stage II technology aircraft for sale within the U.S. beyond January 1, 1986.

AOCI urges the immediate establishment of a federal regulatory program to phase out operations of Stage II aircraft into U.S. airports with a target date of cessatijon of their operations by January 1, 1995. And finally, we urge continuing study of more stringent FAR Part 36 standards to include standards for Stage IV aircraft.

Airport Surface Detection Equipment

Aircraft have the capability, and have had for many years, to autoland in Category III weather conditions. There is, however, no ground based technology to guide the aircraft to the gate. As noted earlier, traffic growth is projected to almost double by the year 2000. This growth cannot be accommodated without the aid of airport surface detection and guidance capability. We urge research in this area.

In conclusion, we cannot over emphasize the importance of airport related research and development particularly as it relates to safety, airport capacity improvement and to the vitality of the nation's air transportation system. As noted earlier in this report,

airport R&D has been severely under funded in part, perhaps, because past budgets have submerged these funds in a much broader categorization and as a result of low priorities, necessary airport research has been neglected. It is important that the FAA Administrator take action that will ensure that a separate line item will be included in future FAA budget submissions for the specific support of airport research activities.

Mr. Chairman, on April 22, 1982, Don Reilly, Executive Director of AOCI, in his capacity as Chairman of the Industry Task Force on Airport Capacity Improvement and Delay Reduction, briefed this subcommittee on the fiscal year 1987 FAA Research, Engineering and Development Budget Request.

We are pleased to note that the report of the House Appropriations Committee on July 17, 1986, announced that the committee recommends an increase of $5.5 million over the budget request for airport capacity research. We find this support very encouraging and we ask for the continued support of this committee so that we can have a stabilized airport capacity R&D program.

Mr. Chairman, that concludes AOCI's statement on airport technology and research needs.

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